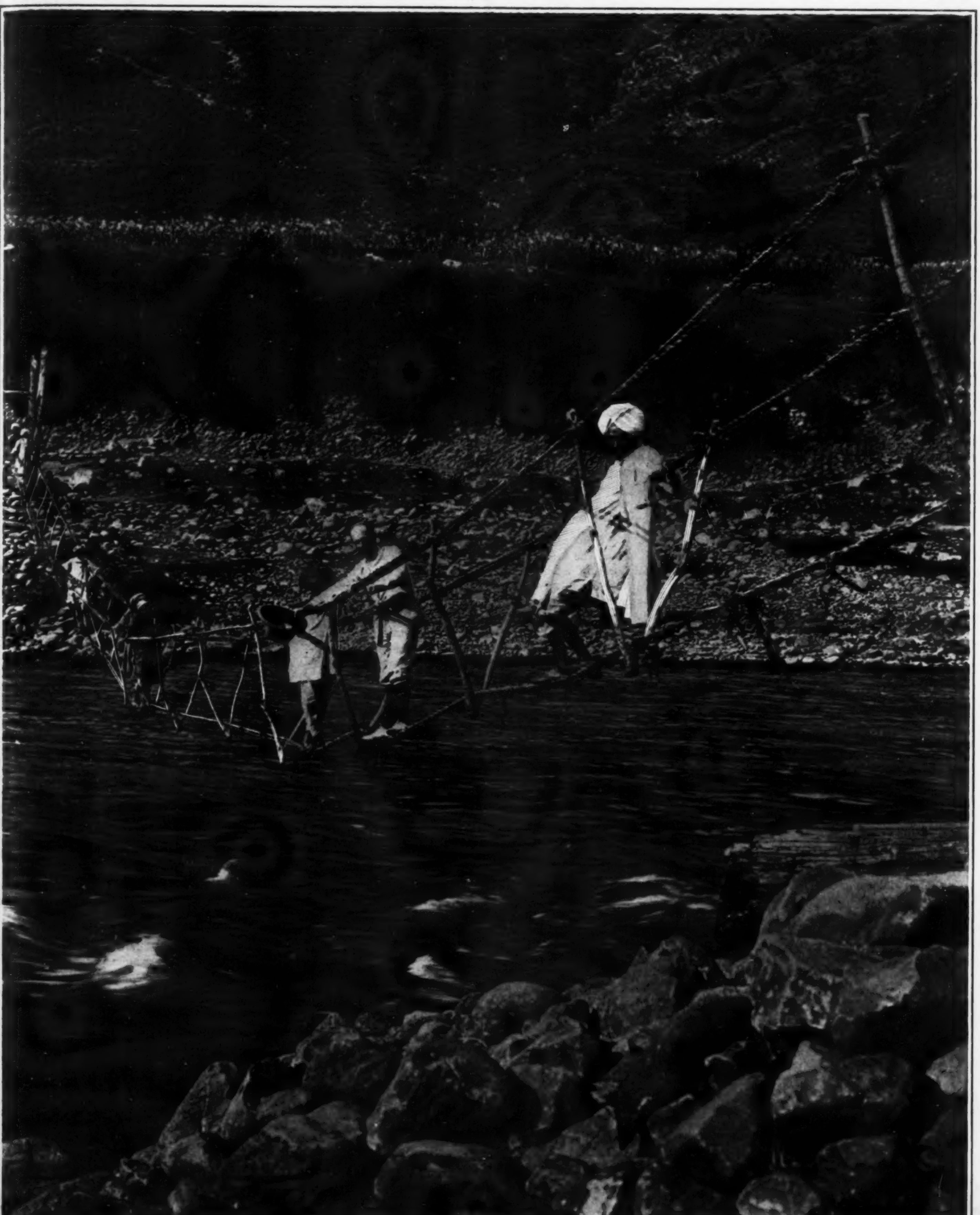
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXXIV
NUMBER 2177

★ NEW YORK, SEPTEMBER 22, 1917 ★

10 CENTS A COPY
$5.00 A YEAR



Primitive Bridge over the Jheelum River in India

SOME OF THE WORLD'S MOST NOTABLE BRIDGES [See page 180]

Osmotic Pressure in Animals and Plants—I*

Difference in Conditions Under Which These Divisions of Living Matter Have Developed

By W. R. G. Atkins, M.A. Sc.D., F.I.C., Assistant to the University Professor of Botany, Trinity College, Dublin

A COMPARATIVE study of the osmotic pressures existing in animal and plant cells reveals at once the great difference in the conditions under which these two great divisions of living matter have developed. And as in their morphology the most primitive of both groups have diverged but litle, so also in their relations with the external medium close similarity may be observed. Again the ontogeny of each species is an abbreviated recapitulation of its phylogeny as far as morphology is concerned. The same is no less true of its physiology, of which the osmotic pressure is an expression.

The nature of osmotic pressure need not be considered here, as indeed much controversy still rages concerning its manner of action. It may be remarked, however, that it can be regarded as a hydrostatic pressure exerted on membranes which limit the diffusion of matter in the crystalloid condition when dissolved in a solvent to which the membrane is permeable. Further its magnitude depends upon the number of molecules of a nonelectrolyte or of molecules and ions of an electrolyte in a given volume of solvent, or more accurately in a given weight of solvent. In this and in its temperature coefficient the osmotic pressure of a dilute solution obeys the gas laws with some degree of accuracy. For concentrated solutions, however, a more complicated equation has been devised, and the gas law equation is a simplified form of this.

Since, therefore, the osmotic pressure of a solution depends upon the total number of ions and molecules in a definite weight of solvent, it is evident that the pressure in a living cell is regulated by the activity of the protoplasm in synthesising colloidal matter from crystalloids and in splitting up colloids again to form crystalloids, as well as by the entrance of external ions or molecules, that entrance itself being regulated by the alterations in permeability of the protoplasmic membrane. Changes in osmotic pressure are therefore an expression of the net result of cell activities in altering the total number of molecules and ions at large in the water it contains.

Measurements of osmotic pressure may be made directly by measuring the hydrostatic pressure developed inside a semi-permeable membrane in contact with the solvent on the other side, or they may be made indirectly by measurements of freezing-point, boiling-point, or vapor pressure of the solution. The connection is evident when one considers that all these constants depend upon the molecular concentration of the solution, and that the same amount of work must be done to change the molecular concentration—and consequently the vapor pressure—of a solution by a definite quantity, quite irrespective of the means by which the alteration is effected. It is therefore immaterial whether the concentration is carried out by forcing a semi-permeable piston through the solution, or by separation of the solvent by freezing it out or by boiling it away.

In physiological investigations two methods have been employed in the main, that of plasmolysis—the balancing of the internal osmotic pressure of the cell against the external osmotic pressure of a non-poisonous solution of electrolytes or non-electrolytes—and that of cryoscopy—the determination of the freezing-point of the expressed contents of the cell.

In the plasmolytic method of determining the osmotic pressure of a plant cell a series of solutions of different concentrations are brought into contact with the cell, until one is found which just forces back the protoplasm from the cellulose wall against which it had been pressed by the osmotic pressure, a hydrostatic pressure, of the cell sap in the vacuole. The osmotic pressure of the sap is then taken to be equal to that of this solution. In reality this gives a slightly high value, as the external solution at first causes a shrinkage of the cellulose walls to their normal dimensions, for they are somewhat distended by the internal pressure.

There are also a number of other sources of error due to the fact that the protoplasmic membrane is but rarely completely impermeable to the solute in the external medium, that at different times this permeability may vary, and that the external medium itself may bring about changes in the permeability. Many of these are reversible and can be repeated over and over again without causing any injury to the cell. The work of Osterhout upon selective permeability, true and false plasmolysis, and the quantitative measurement of the antagonistic action of different ions is of especial interest in this connection. It is, however, too large a subject to be discussed in any detail here.

For these reasons the cryoscopic method is to be preferred when sufficient quantities of the tissue fluid can be obtained unaltered in composition, and when the latter does not undergo any appreciable change during the interval that elapses between expression and the actual determination of freezing-point.

It has already been mentioned that in plasmolysis the protoplasmic layer is forced back from the cellulose wall. Under normal conditions it is this cellulose wall that takes up the hydrostatic pressure or osmotic pressure of the cell sap and sets a limit to the distention of the protoplasm. Without this support the latter would expand owing to the intake of water through it into the vacuole, and would blow out like a soap bubble until it met with the usual fate of bubbles. The analogy is not at all a superficial one, for in each case the enlargement is resisted by the force required to do work, in increasing the surface, against the surface tension of the soap-film in contact with air or of the protoplasm in contact with the external solution. It is precisely the possession of a cellulose wall setting a limit to expansion that constitutes such a profound distinction between plants and animals. For animal cells constancy of the osmotic pressure of the external medium and of the internal fluids is of paramount importance. For plant cells such constancy is quite unnecessary provided always that the osmotic pressure of the external medium is not raised above that of the cell sap to too great an extent or too rapidly.

Consider, for instance, the fate of a protozoan placed in a hypotonic medium; water is absorbed continually till the cell bursts. The same result might be effected by the accumulation of urea or other katabolic products by increasing the internal osmotic pressure, and so causing a relative change, hence the need for an elementary nephric system, such as a contractile vacuole as has been pointed out by Dixon.

OSMOTIC PRESSURE IN PRIMITIVE ORGANISMS

Since the most primitive forms of life developed in water and were devoid of a firm continuous limiting membrane, it is obvious that they must have possessed a very small osmotic pressure. For either they developed in fresh water—in which case their pressure could not have greatly exceeded 0.25 atmosphere, that of moderately hard water freezing at —0.02 degrees C.—or they developed in the sea-water as it was then constituted. The ocean has, however, been growing continually richer in salts owing to denudation of igneous and plutonic rocks. Indeed, the rate of increase of its sodium content has been employed by Joly to estimate the age of the earth reckoned from the time at which water condensed. And although for various reasons all the constituent solutes have not increased at the same rate, and some may even perhaps have decreased, yet the movement of the osmotic pressure has been steadily upwards. The same is true of all water-dwelling animal organisms, so far as the author is aware; their development always involves a rise in osmotic pressure, unless they have a large diminution in the pressure of the external medium superimposed upon their normal condition. Accordingly the naked ova, plant or animal, which develop in fresh water must increase in osmotic pressure from that of their primitive ancestors, namely very approximately the pressure of fresh water, up to that of the mature organism.

OSMOTIC PRESSURE IN ANIMALS

(*a*) *The Lower Water-Dwelling Phyla.*—In all these groups there is contact either complete or partial between the protoplasm and the external medium. Even though a cœlom has been developed in the higher groups, contact is still maintained through the external surfaces, and the nephric system serves to prevent the too great accumulation of solutes. It has been shown by the extended researches of Fredericq, Bottazzi, Quinton and others that all these organisms possess an osmotic pressure equal to, or very slightly higher than, that of the water in which they live. Thus the same species will have a higher pressure when in the Bay of Naples than when in the less saline waters of the Atlantic. The slight excess of pressure inside the organism serves to maintain its turgidity. Since abrupt changes in salinity are often fatal to such organisms, the distribution of particular species is frequently limited in a seemingly very arbitrary manner, whereas the salinity of the particular area in which they live is in reality the factor limiting their distribution. The phenomenon may have indirect results also, for the movements of fishes are in some cases considerably influenced by the distribution of the species of crustacea or other organisms upon which they feed principally.

(*b*) *Fishes.*—In this group the division occurs between those organisms which are at the mercy of the external medium and those which maintain their own osmotic pressure more or less irrespective of outside conditions. The cartilaginous fishes, the elasmobranchs, communicate freely through their gill membranes with the water, whereas the bony fishes, the teleosts, possess gill membranes which are quite, or very largely, impermeable.

Hence it results that in the former class there are sea-fishes and fresh-water fishes. The same fish never passes from one to the other, though it may pass from sea-water to less saline estuarine water; in which case its blood and body salts undergo a change, or its total weight changes, till it is again in osmotic equilibrium with its surroundings. Such changes have been studied among others by Sumner, Bottazzi, and by Dakin.

The teleosts, however, have a mean value for the osmotic pressure of each species, even though there are in some of them quite considerable changes with changing salinity. In the anadromous fishes such as the salmon the impermeability of the gill membranes is of a very high order. For between the osmotic pressure of the fish at sea and in the river there is little or no difference. The eggs, however, are deposited in fresh water, and it is extremely probable that these possess a low osmotic pressure, which gradually increases as maturity is reached. Thus the method whereby the salmon has isolated itself from its surroundings enables it to feed on the abundant life of the sea and to pass again without injury into the safety of the upper reaches of the river for the purposes of spawning. When one considers that the freezing-point of the blood of most teleosts is about —0.6 to —0.9 degrees, corresponding to about 7.2 to 10.8 atmospheres pressure at 0 degrees C., whereas that of the Atlantic is about —2.0 degrees or 24 atmospheres, it is evident that the barrier of an impermeable membrane is very necessary.

(*c*) *Reptiles.*—This class does not appear to have been investigated very fully, but for each species an approximately constant value is found. Some fresh-water forms have pressures of about 5, whereas marine species may go as high as 7 atmospheres. It may or may not be a coincidence that the blood of the fresh-water reptilia is approximately isotonic with the germ cells in the eggs of birds; the latter group has of course developed from the reptilia.

(*d*) *Amphibia.*—The frog has afforded material for so many physiological researches that the osmotic pressure of its blood was determined among the earliest of such measurements. The blood freezes somewhere about —0.46 degrees, so the osmotic pressure is about 5.5 atmospheres. Within the last few years, however, an interesting research has appeared from the Upsala laboratories in which the gradual increase in osmotic pressure of the frog, from spawn through tadpole to the adult condition, has been traced. Thus the stages of the development of the race, so far as osmotic pressure is concerned, are passed through in each individual. In the amphibia, as in all classes from the teleosts upwards, the osmotic pressure is delicately regulated by the nephric system.

(*e*) *Birds.*—Among his numerous researches in this domain of physiology Hamburger determined the freezing-points of the blood of the domestic fowl. Cryoscopic measurements of its, of the duck's, turkey's, and rhea's were also made by the author. It was found that the osmotic pressure of the blood of birds is quite constant for each species, and is higher than that of reptiles and amphibia, being about 7.2 atmospheres. The osmotic pressure of the eggs of several kinds of bird was also determined, and found to be remarkably constant also, provided the eggs were fresh; the magnitude was from 5 to 5.5 atmospheres. During incubation it was found that the pressure of the mixed contents of the egg—and presumably of the embryo also—rose progressively, owing no doubt to the increase in crystalloids arising from the splitting up of complex colloidal molecules. One is tempted to correlate the low pressures found in the adult fresh-water reptilia with the pressures of closely similar magnitude found in the embryo bird. The latter group, abandoning more or less watery surroundings and taking to the air, had

*From *Science Progress*.

to economize in weight in many ways. Perhaps one of these economies was effected by carrying their blood and tissue solutes in more concentrated solution.

(*f*) *Mammals.*—The fluids of physiological importance in mammals have been investigated fairly thoroughly; besides the blood, those most studied have been the milk and the urine. As a whole the freezing-points of the blood of the group lie between —0.55 degrees and —0.60 degrees C., and when one considers the vast amount of anabolic and katabolic changes ceaselessly in progress in the body, such constancy as it met with in each particular species is most remarkable. In fact it is no less wonderful than is the constancy of temperature, the wonder of which is forced upon any biologist who has to construct a thermostat.

In man, for example, the normal freezing-point of blood is —0.56 degrees. It may vary 0.01 degree perhaps in health. After severe hæmorrhage, when the body salts have been lost in quantity, it has within the writer's experience fallen to —0.53 degrees, and even in one case to —0.49 degrees. This is probably the lowest value recorded. In kidney disease, on the other hand, the depression of freezing-point may be greater than the normal. If it is necessary to remove a diseased kidney it is prudent to ascertain first of all that the blood is normal; for it has been found that if the blood freezes at —0.60 degrees or lower when both kidneys are in the body, the removal of one of them is always fatal. For if both together fail to preserve a normal molecular concentration in the blood, the removal of one, even if seriously diseased, results in the production of such accumulation of katabolic toxins as to result in death. Among a limited number of samples of blood from kidney patients submitted to the writer it was found that two exceeded the limit —0.60 degrees laid down by von Koranyi, and by Caspar and Richter. Removal of the kidney would therefore in these cases have been worse than useless. By examining the freezing-point of the urine collected from each ureter separately it is also possible to get a quantitative measure of the functional activity of the two kidneys. In health the values found lie between —0.9 degrees and —2.1 degrees. With diseased organs, however, it is usual to find lower values, —0.6 or thereabouts.

The freezing-point of milk is also, like that of blood, very constant. Winter and Nernst were among the first of many to study it. That of the cow lies at —0.55 degrees, a slightly lower numerical value than that of its blood. Variations exceeding 0.02 degrees are very rare, and seeing that the milk is a secretion from cells in osmotic equilibrium with the blood this is rather to be expected. Over a thousand samples examined in Paris gave the mean value just quoted, which was identical with that found by the writer by testing something under a hundred samples in Dublin. The utility of the test lies in its application to the detection of fraudulent watering, which would bring the freezing-point nearer to that of pure water practically in direct proportion to the amount of water added. Usually the question of adulteration of milk is largely decided by an estimation of its fat content. If, however, this is for any reason low, and the sample gives a normal freezing-point, it is genuine milk beyond any question, unless faking has been carried out by means quite beyond the knowledge of the average dairyman. The cryoscopy of milk has been adopted as an official test in at least one municipal laboratory, that of Amsterdam I believe.

GENERAL DISCUSSION

On the whole, it may be said that the osmotic pressures met with in animal cells do not exceed 7.5 atmospheres, if one excepts those of organisms living in the sea; in these the pressure only slightly surpasses that of the medium, if greater than it; if lower, it is always because the animal has a more or less impermeable membrane which renders it to a certain extent independent osmotically. Within the body, however, each cell of an animal tissue must be considered a water-dweller, being in osmotic equilibrium with the other cells and the inter-cellular solutions.

OSMOTIC PRESSURE IN PLANTS

In primitive naked plant cells, and in free sperms and unfertilised ova, the osmotic relationships with the surrounding medium are much the same as in the animal kingdom.

The advent of the comparatively inextensible cellulose wall introduced an entirely new condition. The cell was free to elaborate solutes to a relatively enormous amount, consequently high osmotic pressures are met with in plants, 15-20 atmospheres being nothing unusual in the foliage leaves of phanerogams. Accordingly as cellulose or very similar substances bound all plant cells except in a few primitive types, differences of osmotic pressure are due to external conditions affecting metabolism rather than to the particular groups of plant in which they occur. Moreover, instead of the osmotic pressure of all the cells of an organism being very nearly equal, as is the case in animals owing to the circulation of the blood and the action of the nephric system, in plants very great differences are met with in the osmotic pressures existing in the different tissues.

[TO BE CONTINUED]

Earth Pressures

The Strange Case of Clay

THE results obtained in a series of experiments on earth pressures were described in a paper by Mr. P. M. Crosthwaite, read before the Institution of Civil Engineers, London.

He remarked that no subject is of more vital importance to engineers than the supporting power of earth and its pressure against walls, for it is scarcely too much to say that of all engineering failures 90 per cent are due to faulty foundations, while it is difficult to estimate the millions that have been expended in making foundations and walls stronger than is necessary to withstand pressures that can be determined only approximately. Probably the best known and most widely accepted theories are those of Rankine, who treats masses of earth and sand as if they were elastic solids. Apparently his theories were based on *a priori* reasoning, and though since his time some experiments have been made to test them, these cannot be said to be entirely satisfactory, since the results vary within wide limits. They do show, however, that the lateral pressure exerted by sand and earth against walls is considerably less than that deduced from Rankine's theory, as usually applied.

The author's experiments were made by loading a plunger with known weights and measuring the penetration into the materials tested when the plunger had come to rest after the application of each weight. The materials were placed in an open bucket and their weight was determined. With the data obtained the value of the angle of internal friction can be calculated from Rankine's well-known formula for the safe depth of foundations, and if his theory is correct the angle of internal friction so deduced should be the same as the angle of repose obtained by observation of the natural slope, and the penetration of the plunger should be directly proportional to the intensity of the pressure.

RESULTS WITH SAND AND EARTH

With sand, garden earth, and cinders and ashes the curves obtained by plotting the pressures against the penetrations were straight lines, but the value of the angle of internal friction was found to vary with the state of aggregation of the material—*i. e.*, whether it was lightly poured into the bucket, shaken in, or well pounded in. When the material was deposited in the bucket as lightly as possible the angle of internal friction was the same as the angle of repose, but with more consolidation it was much greater.

For these materials the author concluded that Rankine's theory holds provided the proper angle of internal friction is used, not the angle of repose. If, however, the former angle were used it would be necessary to introduce a factor of safety into the formula, for a wall designed without one will be theoretically just strong enough and no more. In Rankine's formula there is no factor of safety, but Rankine probably saw that this was the case, though he does not say so, and took the angle of repose as the worst condition that needed to be provided for, giving an ample factor of safety for ordinary working conditions. The author's experiments showed that for the materials tested, work designed by Rankine's formula, using the angle of repose, would have a factor of safety of 2½ to 4.

BEHAVIOR OF CLAY

The experiments on clay gave altogether different results, for instead of the penetration's varying as the load, it varied as the square of the load, and the penetration curves were parabolas. These results, which were altogether unexpected, are completely confirmed by experiments on clay and mud *in situ* by Messrs. Coode, Matthews, Fitzmaurice, and Wilson. These clay experiments were made on a surface one square foot in area and the pressures were carried up to 12 tons per square foot, while those on mud were made on an area of 16 square feet, with pressures of 1¼ ton per square foot. They were carried out on natural undisturbed ground, and showed that the internal coefficient of friction falls off rapidly with increase of pressure.

The author admitted that the behavior of clay under increasing pressures is a complete mystery to him, and he could offer no physical explanation as to why the settlement should vary as the square of the pressure. If the experiments are correct they upset all theories of earth pressure as applied to clay, which assume that the angle of internal friction is the same as the angle of repose, and is independent of the pressure. The subject, he thought, is worthy of further investigation, but it could hardly be undertaken by a private individual. The work is tedious, each experiment requiring 24 to 48 hours; and, further, for the investigation to be properly carried out, physical and chemical analyses of the clays would be required, which could be made only in a well-equipped physical laboratory and should be made by a trained physicist.

The experiments on the softer clays support the suggestion made in connection with the earth-slides on the Panama Canal, that in clay and shale cuttings there is a critical depth below which the sides will not stand. When the value of the angle is independent of the pressure, the depth of the cutting cannot affect the stability and the slope will stand to any height; but where the angle decreases with the pressure, it is evident that eventually a depth and pressure will be reached beyond which the sides of the cutting will not stand.

DEPTH OF FOUNDATIONS

The usual way of applying Rankine's formula for the safe depth of foundations is to calculate the safe depth, excavate and start the footings at this or some greater depth, and assume there will be no settlement, provided the load used in the calculation is not exceeded. But it did not seem self-evident to the author that in view of his experiments this assumption is justified, because in the case of sand a given load produces a given settlement, or penetration, at whatever depth it is applied, otherwise the load-penetration curves would not plot out as straight lines. He, therefore, made a number of tests on this point with damp sand. In the first the sand was well pounded into the bucket, and a load of 12,400 pounds per square foot gave a penetration of 1.95 inches. A cardboard cylinder was then sunk into the sand to a depth of 4½ inches, well below the safe depth, the sand was excavated to the bottom of the cylinder, and an experiment was made with the plunger resting on the bottom of the hole, when it was found that a load of 15,900 pounds per square foot gave a penetration of only 0.25 inch. In view of the possibility that the small penetration was due to the sand's having been compacted in driving the cylinder down, the experiment was repeated, starting the plunger at the surface, when a load of 15,900 pounds gave a penetration of 2.45 inches. A hole was then scooped out in the sand to a depth of 3½ inches; the penetration was then only 0.13 inch.

These experiments, in the author's opinion, prove conclusively so far as is possible by laboratory experiments, that the accepted method of applying Rankine's formula is correct. He had, however, undertaken them with the expectation that they would prove the reverse, and he thought it very surprising that a few inches of sand above the base of the plunger should enable the sand to carry a load of 16,000 pounds per square foot, with practically no settlement. The experiments lead to the somewhat strange conclusion that in sand what carries the weight is the sand above, not that below, the foundations, else the penetration would be the same whether the weight was applied on or at a point below the surface.

Stability and Buoyancy of Submarines

IN a paper before the Institution of Naval Architects, Professor W. Hovgaard discussed some of the problems connected with the buoyancy and stability of submarines, attempting in particular to disentangle the somewhat complicated relations between buoyancy, weight, and stability.

A considerable part of the paper was concerned with the various ballast tanks, with powerful means for flooding and pumping, which are necessary in submarines on account of the requirements for wide and rapid changes in displacement, ranging from a surface condition with considerable reserve buoyancy to a state of complete submersion. The main tanks, which serve to effect the transition from the ready-to-dive to the submerged condition, should constitute by far the greater part of the tank volume: other tanks should not be greater than necessary to allow for variations in weight and buoyancy and will always be relatively small. The tanks should normally be either completely empty or completely full, and a free surface should exist in them only during the process of flooding or emptying. In certain cases of emergency, as, for instance, when the boat is damaged or when for some reason it tends to dive below the maximum designed depth, it may be required to produce with certainty a great and sudden rise of buoyancy. For this purpose one of the main tanks, called the safety or emergency tank, is so fitted that its water may be expelled by means of compressed air or a special pump capable of working against a high pressure.

Some of the World's Most Notable Bridges

AMONG the engineering and architectural works of man, the bridge is one of the oldest, the ruins of Egypt and even of Mesopotamia revealing the use of this form of structure in the earliest recorded times. In all likelihood, the most primitive bridge was the tree or log thrown across a stream, and it is not unlikely that when stone came into use as a building material, bridges of moderate span were formed by the use of long slabs of this material resting upon opposite banks or upon crude stone abutments. The stone or timber lintel of a door-way, indeed, is a bridge construction of this simple type.

The earliest indications of the arch bridge have been found in Egypt and the Euphrates valley, where the inclinations of two straight slabs meeting at the top, as discovered in recent explorations, shows an early, if crude, form of arch construction. Judging from such remains as have come down to us, the Romans, those master engineers, must have had a thorough knowledge of the principles of arch construction, and they have left some noble evidences of their skill, both in the arch bridge and the dome, the materials in both cases being stone or concrete. Arched masonry road bridges were built freely throughout the Roman Empire, and many of them are standing and in use today, both on the Continent and in the British Isles.

Because of the weight, there is a constructive limit to the span of masonry bridges, and, thus far, about 300 feet seems to be the maximum length to which they can be built; although designs were drawn in the New York Bridge Department for a reinforced-concrete arch over the Harlem River at Spuyten Duyvil, New York, whose span was over double that length.

The advent of steel, with its higher strength in proportion to its weight, enabled the engineer to build arch bridges of a hitherto undreamed-of span. During the past three decades some notable and very handsome steel arch bridges have been constructed in which the span has been carried up, first, to 500 feet and over and finally to 1,000 feet. Among spans of approximately 500 feet may be mentioned the Washington Bridge, over the Harlem River—the Eads St. Louis Bridge, over the Mississippi—the double-deck bridge over the Douro River, at Oporto, Portugal—the bridge over the Zambesi, South Africa, which, by the way, is highest above the chasm which it crosses of any existing bridge.

The next advance was seen in the construction of the steel-arch bridge, which replaced the old wire suspension bridge across the Niagara River below the Falls, which has a span of 840 feet. This has provision for vehicles, trolley cars and foot passengers.

The greatest arch bridge in existence is the massive four-track railway bridge which crosses the East River at Hell Gate and forms a part of the connecting railway which unites the New Haven and Pennsylvania railroad systems at New York. It consists of two parallel arched trusses, from which is suspended a solid roadway upon which are laid the stone ballast and ties of the standard Pennsylvania railroad track construction.

An interesting type of bridge, which has had a considerable vogue in Europe, is the bowstring truss. One interesting variation of this type is to be found in the handsome structure which crosses the River Elbe, at Hamburg. Each span consists of two double-arched trusses, the lower of which is inverted.

One of the most economical and serviceable types of bridge is the suspension, and probably, in its crudest form, it is one of the most ancient. We present an illustration of a primitive construction of this kind which forms the means of crossing the Jheelum River in India. It consists of six stout ropes of native manufacture in pairs, the bottom pair forming a footrope and the other two the handrope, the three being held in a position by a series of wooden forks, which are lashed securely to the ropes and serve to hold them in their proper relative position.

It was not until the coming of the age of modern iron and steel manufacture that it was possible to develop the inherent possibilities of the suspension system for bridges of long span. In the earliest of these bridges the suspension member consisted of flat bars or links, which were pinned together to form chain cables. Some notable bridges of this type were built in England, one of the earliest of which is the famous old chain bridge across the Menai Straits, designed and built by Thomas Telford in 1820 to carry the post road from the main land to the Isle of Anglesea. On the same road was built at Conway another bridge of this type, and the architect had the good taste to design the towers and abutments to conform to the architectural features of the nearby Conway castle. Another interesting chain suspension bridge is that over the River Avon, at Clifton, Bristol, England. The chains for this bridge formerly formed part of a bridge across the Thames at London.

A picturesque bridge at Lucerne, Switzerland

The introduction of iron and latterly of steel wire with its high tensile strength, rendered it possible to build suspension bridges of hitherto unprecedented length. Roebling, over 30 years ago, conceived the bold idea of crossing the East River with a wire suspension bridge and he translated his dream into a splendid reality by successfully erecting the present Brooklyn Suspension Bridge, which, after over 30 years of service, is carrying loads far in excess of those contemplated by its designer. The clear span between towers is 1,930 feet. Subsequently there have been built across the East River the Williamsburg Bridge of 1,600 span and the Manhattan Bridge of 1,470 foot span.

The triangulated truss bridge, self-contained and carried on end supports, is the type which more than any other has been used in solving the problem of crossing broad rivers and wide chasms, both for highway and railroad construction. In present practice the plate girder bridge is used in spans up to about 175 feet, the truss bridge from 175 to 700 feet, the cantilever from 700 to 1,800 feet, which is the span of the great Quebec Bridge, and the suspension bridge is found to be the most economical for spans of from 1,500 to 2,000 feet or over. Lindenthal has designed a bridge across the North River with a span of 3,200 feet, which should the necessary capital be found, will undoubtedly be built.

Perhaps the most notable bridge, today, is the great cantilever structure over the Firth of Forth, Scotland, designed by the late Sir Benjamin Baker. It has two clear spans of 710 feet and it is so strong and stiff that a heavy express train service is run across it, daily, at speeds of 60 and 70 miles an hour.

Curious old swinging bridge over the Huari River, Peru

Potash from Seaweed

OBTAINING potash from seaweed in the Sargasso Sea is a project which is to be undertaken by W. S. Warner of Tampa, Fla. Mr. Warner was formerly a sea captain, and has also done work in the development of the Florida phosphate deposits. He plans to build an 8,000-ton vessel of reinforced concrete, 300 feet in length, 50 foot beam and 24 foot depth of hold. The vessel is to be subdivided by bulkheads into water-tight compartments, and is to be equipped with machinery for hoisting the seaweed from the ocean and reducing it to ashes. As the seaweed is raised from the water, it will be run through three successive sets of heavy rolls which will remove 85 per cent of the surplus water which it contains. After passing through rotary drying kilns, the seaweed will be burned and the ashes, in which the potash content is concentrated, will be discharged into the hold of the vessel. The equipment is planned to be capable of hoisting, drying and burning enough seaweed to produce 200 tons of ashes per day. Captain Warner claims that the Sargasso Sea is a region of such continuous calm, with freedom from both wind and wave, that the work can be carried on continuously without interruption, and there will be no difficulty in transferring the accumulated ashes from the seaweed-gathering barge to the steamers which will visit it regularly to transport the ashes to shore. The amount of seaweed in the Sargasso Sea is so vast as to be beyond estimation. Steamers, however, can navigate the sea and the patches of seaweed in it are not continuous.—*Engineering News.*

Integrating Tachometers*

By Commander L. A. Kaiser, U. S. N.

NAVAL vessels, from the nature of their service, operate together in formation underway. To attain and maintain correct position in formation the necessity arises of providing means of controlling the speed of the engines and this, in turn, presumes means of *measuring* or *regulating* speed. *Regulating* devices for main engines at the present time are neither practical nor desirable, but it is possible they may be built, in the future development of the electric drive. The different methods of revolution measurement fall into two general classes: First, *differential* speed indicators, which show the speed at any instant, or at successive instants; second, *integrating* speed indicators, which, by summing up the movements of the shaft, show the amount lost or gained in an interval of time.

The numerous types of speedometers—centrifugal, electric, magnetic, etc.—are examples of the first class; also the first and most primitive method of measuring revolutions (simultaneous reading of the engine-room counter and clock). Recently highly developed forms of the latter type have been brought out in which the "counter and clock" method is hardly recognized, but on examination of the underlying principles the identity is perceived. In slow-moving engines it was probably exact enough for the man on watch at the throttle to *count* the number of revolutions (or watch the counter) during a prescribed interval of time, say one minute or five minutes; in later types this is accomplished *mechanically*. It is, of course, necessary to watch the indicator constantly or else assume that the speed when unwatched is the same as that at the instant of observation.

In the *second* class, the *integrating* speed indicators variable gearing as a rule is interposed between the shaft and a pointer which revolves concentrically with a pointer revolved by clock work (the second hand of a clock); the speed indicator being set for the desired number of revolutions, the engine or shaft pointer is kept in line with the clock pointer, in the same way that the port and starboard engines are kept together by the revolution pointers or tell-tales (usually mounted on center-line bulkheads). There is no necessity for *constant* observation, as the movement of the engine pointer in the integration of the motion of the shaft, and a gain or loss is manifested by the separation of the hands as in the engine tell-tales or revolution indicators; by operation of the throttle, bringing the engine hand coincident or in line with the clock hand, the average revolutions prescribed are maintained. An integrating speed indicator will therefore show at any time that the prescribed speed has been maintained, or that the engines have been *gaining* or *losing* and, further, the *amount* of gain or loss.

A differential speed indicator shows the speed at the *moment of observation only*.

There is also this distinction in the *functions or capabilities* of the integrating speed indicators, and as it has an important bearing on the tactical question of maintaining position in formation it will be explained with some detail.

With an integrating speed indicator it will be shown it is possible for the *engine room to gain or lose distance as directed from the bridge*. The bridge determines by stadimeter, or otherwise, that the ship is *ahead* or *astern* of position, and directs the engine room to *lose* or *gain*. By consulting a previously prepared table kept near the throttle the man on watch sets the *engine hand ahead* or in the *rear* of the clock, and then by the throttle causes the engine hand to *lose* or *gain* until it is in coincidence.

If the variable gearing is so designed that the engine hand makes *one revolution per minute* when the engine is making the prescribed speed, then it is evident that it is simply necessary to keep the engine hand coincident with the second hand of a clock (which also makes one revolution per minute).

To gain or lose distance, then, set the *engine hand* a certain number of seconds in *rear* or *advance* of the second hand and bring in coincidence with the throttle. The number of seconds to gain (or lose) ten yards is determined by the following formula:

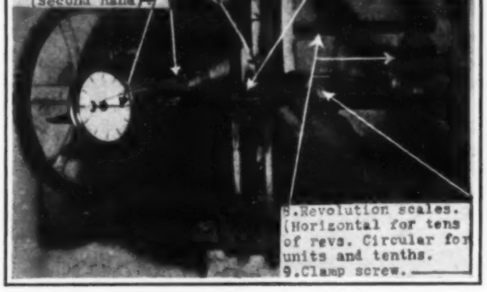
$$S = \frac{10 \times 60 \times 3}{R \times P} = \frac{1{,}800}{R \times P}$$

where

R = Revolutions per minute at the time;
P = Pitch of propeller in feet;
S = Seconds.

Upon consideration, it will be perceived that this procedure (of making the *engine room* gain or lose distance) is a *natural* process in the work of maintaining position. The bridge determines by observation the distance to be gained or lost, and *distance* is an integral function of *speed*; the *source* of power to make speed or distance resides in the engine room. The bridge, in estimating the number of revolutions to gain or lose distance, deliberately or unconsciously performs a mental process which can be performed to better advantage in the engine room; first, because it can be worked out in tabular form; and, second, for the practical consideration that the engine room operates the motive power which is to produce the desired results. The *bridge* should be divested of all activities which can be performed elsewhere, especially if to better advantage.

The following extract from the report of a Board composed of senior engineer officers on the armored cruiser squadron of the Pacific Fleet gives a clear idea of the construction of the first instrument installed on the "Washington" some years ago. "The device consists essentially of a 12-inch flat disk of steel driven by a 4-inch wheel perpendicular to its face and which is driven by a shaft connected by small gear wheels to the starboard revolution indicator. The distance of the driving wheel



from the center of the large disk can be varied by a screw of ½-inch pitch. On this screw is placed a scale of revolutions. A clock of 4-inch dial with a lone second hand is placed over the center of the large disk, the latter carrying a U, over the ends of which an elastic band is stretched across the face of the clock. When the revolutions of the main engines agree with the pointer on the scale the disk should make one revolution per minute, the U pointer exactly following the clock hand, and, conversely, by moving the scale indicator until the U pointer exactly follows the clock hand the number of revolutions of the main engine can be read from the scale.

"The device on board the 'Washington' has been constructed and installed by the ship's force under the direction of Lieutenant-Commander Kaiser, the castings being furnished from navy yards. It has been in use for nearly a year, during which time the ship has cruised 20,000 miles, generally in squadron, both as guide and following ship. The operation of changing the index to agree with deck signals can be made in an instant, and experience shows that even green men can be quickly trained to make the disk hand follow the clock hand, thus insuring regularity of speed. An error in the clock rate would make a small error in the exactness of the total revolutions, but they would still be uniform, which is most to be desired.

"The device is stoutly constructed, with no delicate parts and few wearing parts that would ever require renewal. The large disc is pressed against its driving disc, which is knurled on the circumference, by a U spring of variable tension with an idle wheel, so that there appear to be no slip. The large disc would probably become grooved and rough on its driving face, requiring renewal perhaps once a year. (See photograph.)

"The Board is of the opinion that constant and regular revolutions can be maintained by this device and that it is particularly valuable to the guide ship; that it materially shortens the time of adjusting the revolutions to either large or small changes of speed, thus making it valuable to following ship; its scale is a constant index of the number of revolutions being made; it shows the officer on watch in the engine room at a glance whether the revolutions have been as desired for a past interval as it shows the accumulated error."

An instrument was built from "Washington" blue-prints and installed in the "Connecticut" during the battleship cruise around the world. The fleet engineer reported: "The cruise of the fleet has demonstrated the necessity for some instrument which will show the exact speed of revolutions of the engines at any time. Such an instrument would make it possible for the engines to be run at constant speed, and in changes of speed enable the man at the throttle to take up new speed with practically no loss of time in counting revolutions, as at present.

"The only error noted up to date has been so small as to be practically negligible, due to the inaccuracy of the two-dollar lone hand clock used with the tachometer."

The character of the traction surfaces—the surface of the disk and the rim of the driving wheel—has an important bearing on the correct functioning of this instrument. It has been found by experience that best results are obtained by making the disk of a saw-steel blank and making the *rim* of the driving wheel of small radius and of hardened steel. In pouring a stream of oil over the point of contact and also in coating the face of the disc with lard no *slip* was discovered. If the *disc* is soft and if the *rim* is *broad* the contact *point* becomes a *line* of *doubt* in a radial direction on the disk; the outer and inner radial points travel at different *linear* speeds. Setting up on the tension device therefore only aggravates the difficulty. This occurred on some instruments originally supplied. The remedy is simple.

It was apprehended by some that the driving wheel would wear a groove in the disk if the engine were run a long time at one speed. In an instrument constructed on board the "Montgomery" from parts supplied by Cory & Son, the maximum error found when set *one-tenth* of *one turn* on either side of 105 (at which the engine had been run for a large number of revolutions) was one-sixth of one per cent; the average was much smaller. In this instrument the disc had been made half size (as compared to that on the "Washington" so the error would be doubled. Experience shows that a disc of six-inch or even four-inch radius is large enough.

With an A. C. generator driven by the main shaft (or the averaging shaft of the engine revolution counter) and a synchronous motor which will start from rest and keep step, without hunting, a reliable means is supplied by which the speed condition in the engine room can be reproduced on the bridge and in the central station or elsewhere. Such a power-transmission device is understood to have been developed. It is highly desirable that an efficient speed control should be provided, especially in our battleships, by which the "caterpillar" movement down the column may be minimized; it is moreover a tactical *necessity* of prime importance, and of growing importance, if high-speed ships of large tonnage are to maneuver at close intervals efficiently and with safety.

*Journal of the Am. Soc. of Naval Engineers.

Rivets in Ships

IT is rather curious that riveting, one of the most troublesome processes in shipbuilding of the present day, is carried out on the same principle as it was when iron ships were first constructed. Not only do rivets form an undesirable method of connecting together ship plates and angles, but the labor troubles in connection with them are more acute than in any other trade. At their best riveted joints are crude, and while constant use has made shipbuilders accept all the troubles connected with them as a matter of course, these troubles are very numerous. Apart from the ordinary troubles with riveters themselves, as ships increase in size rivets become larger and larger until they are extremely difficult to handle by manual labor at all. Their employment leads to the addition of a multitude of small weights due to laps, butt straps, angle bars, doublings, corner pieces, etc., and at the same time there is created a non-uniformity of strength and elasticity throughout the whole structure. Further, since a plate is weakened by a line of rivets, the main part of it must be made much stronger than is really necessary, and if there were no weakness the whole of the scantlings could be reduced. In working up the strength of a ship deductions are made for the weakening of the structure brought about by the rivet connections, and actually it represents quite a fair percentage. A good deal of attention has been given in the past few years to welding processes with iron and steel, but in ships their use has been limited to welding landing edges of leaky seams, bulb frames, and cracks in stern and rudder posts, and to building up worn rudder pintles. These processes, however, do not touch the main problem, and while it seems at present quite out of the range of practical politics to dispense with rivets, there is undoubtedly a large field here for research work which might well be taken up by the shipbuilders and shipowners of this country. —*The London Times Engineering Supplement.*

New Fuel for Navy

VAST quantities of smokeless fuel are believed to be available for the United States Navy by the discovery that anthracite culm mixed with 20 per cent of soft coal burns fiercely and produces none of the smoke which soft coal, now generally in use in the service, gives forth. Often a naval vessel is detected by the immense amount of smoke coming from the stacks at certain times, and it is believed that smokeless fuel would be almost as valuable as smokeless powder. Since the discovery has been made that a mixture of anthracite culm and bituminous coal can be burned without smoke, large quantities of culm are being shipped from Pottsville, Pa., to New York, there being a large demand for the product in this city.—*Daily Marine Record.*

A Substitute for Litmus for Use as an Indicator in Milk Cultures*

By Wm. Mansfield Clark and Herbert A. Lubs, of the Research Laboratories, Dairy Division, Bureau of Animal Industry, United States Department of Agriculture

THE color changes which occur in litmus-milk cultures may be due not only to changes in the hydrogen-ion concentration of the medium but to reduction or even destruction of the dye. Thus, in any given case there may be obtained a composite picture which may happen to be more or less characteristic of a particular organism but which at the same time is difficult to analyze. It is not to be denied that such a complex picture may be of some value to a trained observer, but its complexity obscures that clear and simple view which should distinguish a good cultural test.

Dibromoorthocresolsulfonphthalein, which the writers have described as a reliable and brilliant indicator for the colorimetric determination of hydrogen-ion concentration,[1] is reduced with difficulty. In most cases it may be used even in the presence of active bacterial growths without being appreciably reduced, and it will therefore continue to show changes in the reaction of the medium without the confusing effect of reduction.

For laboratory parlance the writers have suggested that dibromoorthocresolsulfonphthalein be called "bromcresol purple." Its preparation has been described in previous papers,[2] and it may now be purchased in this country; but in purchasing this compound the full chemical name should always be used. For ordinary indicator purposes a 0.04 per cent aqueous solution of the monosodium salt is recommended, but as a stock solution for the present purpose a solution of the salt containing 0.5 per cent of the acid is suggested.

This solution may be prepared as follows: 0.5 gm. dibromoorthocresolsulfonphthalein should be ground to a fine powder in a glass mortar and 14 c. c. of *N/10* sodium hydroxid added, and the mixture stirred well. This is approximately 1.5 equivalent parts of sodium hydroxid. The mixture should be diluted to about 90 c. c. with distilled water, shaken until solution is complete, and then made up to 100 c. c. with distilled water. The manufacturer should furnish material which when treated in this manner will provide a clear solution free from the odor of cresol.

A satisfactory concentration for coloring milk is about 0.005 per cent and is obtained by adding 10 c. c. of a 0.5 per cent solution to 1 liter of milk. Since the molecular weight of the sodium salt of dibromoorthocresolsulfonphthalein is 562, the above-described concentration is approximately M/10,000.

The color of milk containing about 0.005 per cent of bromcresol purple may be approximately described as a deep glaucous gray.[3] After sterilization for 20 minutes at 15 pounds' pressure, the color is a tea-green.[3] When an alkali formation occurs, the color goes through a series of blues, while in the case of an acid fermentation the color changes to yellow. If the milk is digested, the color of the indicator stands out clearly, but it is difficult to describe by reason of the dichromatic nature of the transmitted light, which the writers have explained in a previous paper.[4]

The cost of the new indicator is a factor which must be considered by those who use extensively an indicator in milk cultures. In 1916 a manufacturer made for the writers some bromcresol purple at $2 a dram. At that price it costs 10 cents to color a liter of milk with the concentration of dye which is recommended. In the same year they purchased azolitmin at $5 an ounce. If that dye is used in the customary concentration of 0.1 per cent, it costs, at the price given above, about 17½ cents to color a liter of milk. Crude litmus is, of course, very much cheaper, but the quality purchasable is not very satisfactory. As is well known, litmus and azolitmin have lost prestige in the modern chemical laboratory, and for that reason there is little incentive for the manufacturers to improve the quality of the samples placed on the market.

It should be noted that the price paid for bromcresol purple was out of all proportion to the current costs of the raw materials at the time and to the cost of manufacture. It represents the trouble and risk in manufacturing and marketing a new product for which at the time the demand was very small. A fair estimate of the cost can not be made at present.

When litmus milk is sterilized, the litmus undergoes a temporary reduction. In some laboratories whole milk is used for special purposes. In this case the cream layer which is formed delays the diffusion of oxygen, and the reoxidation of the dye becomes a slow process, involving considerable delay in the use of the litmus-milk tubes. Bromcresol purple does not suffer such a reduction, and consequently milk tubes containing it are ready for use directly after sterilization.

The range of P_H within which bromcresol purple exhibits its color changes is well suited to the P_H values of milk cultures, which is not entirely true of litmus and azolitmin. There are found in the literature various directions for "adjusting the reaction" of milk in order to bring out a favorable color with litmus or azolitmin.

Litmus is seldom pure, and even azolitmin has been reported to be of uncertain composition. Bromcresol purple can be obtained in crystaline form. When one considers the relatively high concentrations in which litmus must be used and the very high dilutions in which bromcresol purple is serviceable, it is evident that, if the introduction of impurities is to be avoided, the advantage of bromcresol purple is great.

The impurity in a litmus preparation often changes the P_H of the milk to which it is added. Because of considerable variation in the quantity of impurity, it is difficult to obtain the same color in different batches of litmus milk even when the milks, the actual concentration of dye, and the time and temperature of sterilization are constant. Since fresh milks are fairly constant in their initial P_H, while litmus preparations have variable neutralizing power, Dr. P. Rupp, of the Dairy Division, has found it advisable to adjust the neutralizing power of the litmus solution rather than to attempt any adjustment of the P_H of the milk either before or after the addition of the litmus solution. By this procedure he has been able to increase very materially the reproducibility of the color in litmus milk.

Bromcresol purple is obtainable now in very pure form, and the ability of a low concentration of its sodium salt or of the acid itself to change the P_H of milk is practicaly nil; consequently, when it is added to milk in the concentration recommended, no adjustment of the dye solution, of the milk, or of the mixture is necessary.

Particular attention should be called to the fact that milk is not suited to accurate estimations of its hydrogen-ion concentrations by the colorimetric method. This is chiefly because the turbidity of milk is so intense that it can not be compensated for in making the comparisons with the clear, colorless standards. There is also a probable "protein" error. None of the methods which we have successfully applied to other colored and turbid-culture media has proved to be very successful when applied to milk. These considerations reduce but do not wholly destroy the value of comparative measurements. Even though a definite P_H value can not be assigned in the reaction in any particular culture, the direction of the fermentation and, roughly, its intensity can still be determined.

A much more serious aspect of the subject is the considerable change in P_H which occurs when milk is sterilized and the consequent difficulty in reproducing a particular initial color in different batches. Quite aside from the temporary reduction which occurs when litmus milk is sterilized, there is a permanent color change which must be ascribed to the change in the hydrogen-ion concentration of the milk. A similar change in color will be observed when milks containing bromcresol purple are sterilized. That this is due to change in hydrogen-ion concentration is shown by the following experiment: Two equal portions of the same sample of fresh-skimmed milk were autoclaved, one sample with bromcresol purple present, the other with the indicator absent. After sterilization the uncolored sample received the same quantity of indicator that had been added to the first sample. The two samples of heated milk then had the same color. Both showed in like degree a change from the color of an unheated control containing the same concentration of indicator. The change in P_H which occured during sterilization was measured by means of the hydrogen electrode. The value of the unheated sample was $P_H = 6.60$, while that heated in the autoclave at 17 pounds for 15 minutes was 6.36. When the unheated milk was acidified until its P_H value was close to that of the heated milk, the two samples matched almost perfectly in their color with bromcresol purple.

These observations indicate quite conclusively that the color change which occurs when milk containing bromcresol purple is heated is due to a change in the hydrogen-ion concentration of the milk, and that it is not due to an alteration of the indicator itself. The same conclusion holds for the permanent color change in litmus milk. This is supported by the fact that the different degrees of color change which occur when milks are heated for a longer or shorter period or at higher or lower temperatures are proportional to the changes in hydrogen-ion concentration accompanying these treatments. It should be noted that in the more severely treated milks there is a coloration of the milk itself, which is superimposed upon the color of the indicator.

It is also important to note that the changes in the reaction of milks which are brought about by sterilization may be considerable. It has been stated above that a sample of milk with a P_H value of 6.60 was changed to $P_H = 6.36$ during 15 minutes' sterilization at 17 pounds' steam pressure. A duplicate sample, when held for 15 minutes longer at that pressure, had a P_H value of 6.13. What the variation may have been in milks of diverse qualities, treated with litmus solutions of various degrees of impurity, adjusted with different additions of alkali or acid, and heated at various pressures for different lengths of time, it is quite impossible to say. The variations may not have been important for crude cultural tests of most organisms, but in the study of certain ones it is entirely possible that at times the reaction was brought to the border of or placed outside the optimum range for growth.

In the utilization of milk as a culture medium it may be found advantageous in particular instances to adjust its initial P_H to some point other than that obtained in sterilized fresh milk. The writers have found, for instance, that if milk is to be brought to P_H 7.0 when sterilized, bromthymol blue is more serviceable than bromcresol purple. For most purposes it will be found advantageous to adhere to the use of fresh, unadjusted milk containing some definite quantity of bromcresol purple. If, then, the temperature and time of sterilization are kept constant, the color of different batches will be reproducible. This implies that the initial P_H will be the same in all cases. So far as this affects the growth and metabolism of a culture, it is important that it should be reproducible, which it certainly is not when the procedures that have been used in the preparation of litmus milks are modified at will, with no very clear conception of the important aims.

The possible usefulness of diluted milk has not been fully appreciated. While our own experiments have been very few, the writers think that one or two of the more general aspects of the subject are worthy of notice.

Dilution of milk tends to raise the P_H. In certain instances this may be a distinct advantage and a better way of adjustment than the addition of alkali. In one preliminary experiment it was found that the change in P_H during the sterilization of a milk diluted five times was less than that in the undiluted sample. The most suggestive aspect of the subject is the relative buffer effects in diluted and undiluted milk. The buffer effect of milk is considerably higher than that of most culture media.[5] Consequently a culture must elaborate an unusual quantity of acid or alkali to induce a given change in P_H and a consequent change in the color of of an indicator. By diluting the milk the relative buffer effect is lowered, and a proportionally smaller degree of acid or alkali fermentation is required to induce a given change in the indicator color. Dilution also permits a better view of the color.

*Journal of Agricultural Research, Washington, D. C.

[1] Clark, W. M., and Lubs, H. A. The Colorimetric Determination of Hydrogen-ion Concentration and Its Applications in Bacteriology. Pt. I-III. *In* Jour. Bact., v. 2, no. 1, p. 1-34, fig. 4; no. 2, p. 109-136, fig. 5-7; no. 3, p. 191-236, fig. 8, 1917. References, v. 2, No. 3, p. 233-236.

[2] Lubs, H. A., and Clark, W. M. A Note on the Sulphonephthaleins as Indicators for the Colorimetric Determination of Hydrogen-ion Concentration. *In* Jour. Wash. Acad. Sci. v. 6, no. 14, p. 481-483. 1916.

[3] Ridgway, Robert. Color Standards and Color Nomenclature. Washington, D. C., 1912.

[3] Idem. Pl. 47.

[4] Clark, W. M., and Lubs, H. A. 1917. Op. cit.

[5] Clark, W. M. "The Reaction" of Bacteriologic Culture Media. *In* Jour. Infect. Diseases, v. 17, no. 1, p. 109-136, 7 charts. 1915.

Obviously such facts are not the only ones to be considered, and in lieu of sufficient data to permit a systematic treatment of the use of diluted milk, the writers will confine themselves to the presentation of a series of experiments with cultures in undiluted skim milk in which the relative value of litmus and bromcresol purple was tested.

The organisms used were several acid-forming cultures of *Bacillus coli*, *B. aerogenes*, *B. bulgaricus*, and streptococci, three alakali producers of Mr. S. H. Ayers, of the Dairy Division, some cultures of *B. proteus*, and the following pathogenic bacteria kindly sent to the writers by Prof. C. E. A. Winslow from the collection of the American Museum of Natural History:

Bacillus paratyphi	"B"	No. 22
Do.	"B"	No. 323
Do.	"A"	No. 16
Do.	"A"	No. 294
Bacillus typhi		No. 607
Do.		No. 608
Bacillus enteritides		No. 18
Do.		No. 25
Bacillus dysenteriae	"Strong"	No. 196
Do.	"Shiga"	No. 197
Do.	"Flexner"	No. 110
Do.	"Kruse"	No. 121

Observations were also made with a strain of the anthrax bacillus furnished by Dr. R. A. Kelser, of the Bureau of Animal Industry, and a strain of *B. abortus* given by Miss Alice C. Evans, of the Dairy Division.

Observations were made at 40, 26, 48, and 72 hours after inoculation and from then on at various periods for a month. Incubation temperatures were appropriate to the organisms studied.

It is almost impossible to describe the color of indicator solutions by means of Ridgway's color charts[6], and there are no standards which may be used satisfactorily with milk for determining colorimetrically P_H values. The writers must therefore be content with saying that no change was observed in the litmus-milk cultures which could not be seen so well with milk colored with bromcresol purple. In a few instances a more rapid change was observed in one case than in another, but this may be ascribed either to the peculiarity of an individual culture or to a more favorable initial P_H in the one case or the other.

A noteworthy example of the higher value of bromcresol purple was observed when comparing cultures of *B. coli*, streptococci, and *B. bulgaricus*. As the senior writer noted in a former paper,[7] *B. coli* cultures do not attain the same hydrogen-ion concentration in milk that they attain in other media. The writers now observe that even when they bring milk to the point of coagulation the bromcresol purple is left with a tinge of glaucous gray. Streptococcus cultures which in milk arrive at a higher hydrogen-ion concentration give to the bromcresol purple a clear cream color. Cultures of *B. bulgaricus* produce so much higher reaction that the cream color of a streptococcus culture gives place to a maize-yellow.[8] So beautiful a gradation of color change is entirely lost in litmus cultures.

In those cases in which a digestion of the milk occurs there is a very marked change in the quality of the color, owing to the fact that as turbidity is removed greater depth of the solution is observed, and, instead of the transmitted blue of the indicator being dominant, as it is in thin layers of solution, the transmitted red becomes more noticeable. This change may prove confusing to one who is unfamiliar with this indicator, but one who is familiar with its colors in various solutions and in the colorless standards of known P_H may still follow approximately the degree of alkali or acid production.

The most noteworthy advantage of bromcresol purple observed in this series of comparative tests with litmus was found to be the resistance of the new indicator to reduction. In very few instances was any serious reduction or destruction detected. While litmus seemed to be decomposed in a variety of ways with the production of mere muddy colors, in many instances bromcresol purple continued to indicate changes in P_H, as a good indicator should. This alone is a sufficient reason for recommending that it be substituted for litmus in milk cultures and in similar instances in which it is considered advisable to have an indicator present during a fermentation.

SUMMARY

The color changes which occur in litmus-milk cultures may be due to changes in the hydrogen-ion concentration of the medium or to reduction or even destruction of the dye. If it is the degree of acid or alkali fermentation which is sought, it is advisable to use an indicator which will not be affected except by a change in the hydrogen-ion concentration. Dibromoorthocresolsulfonphthalein, for which the short name bromcresol purple is suggested, fulfills this condition.

Litmus undergoes a temporary reduction during sterilization in the presence of milk. Bromcresol purple does not.

The coloring power of litmus is relatively weak; bromcresol purple in very high dilution is useful.

Litmus and azolitmin are indicators of uncertain composition; bromcresol purple is a definite individual compound obtainable in crystaline form and therefore reproducible. Its cost is not excessive.

The impurities of litmus preparations vary in their effect upon the P_H of milk and often necessitate elaborate adjustment either of the litmus solution, of the milk, or of the mixture if reproducible color is to be obtained. Bromcresol purple, on the other hand, may be used with the assurance that, if other conditions are constant, it will always produce the same coloration.

Some of the difficulty experienced in reproducing a particular initial color with either indicator is shown to be due to the changes in P_H which occur when milk is sterilized by heat.

The comparative value of litmus and bromcresol purple in milk cultures was tested with a variety of organisms. It was found that no change in reaction could be observed with litmus which could not be followed equally well with bromcresol purple. In many instances litmus was rendered useless by reduction or destruction while bromcresol purple continued to act as a true indicator of the hydrogen-ion concentration.

[6] Ridgway, Robert. Op. cit.

[7] Clark, W. M. The Final Hydrogen-ion Concentration of Cultures of Bacillus Coli. *In* Jour. Biol. Chem., v. 22, no. 1, p. 87-98, 1 fig. 1915.

[8] Ridgway, Robert. Op. cit., pl. 4.

Peat as a Coal Substitute

Among the various suggestions that have been made from time to time with a view to trying to find a suitable substitute for coal, the feasibility of using peat has been raised on many occasions, but hitherto, both for commercial and mechanical reasons, its practical utilization has failed. Probably one reason for failure is that it is not generally known how to convert the raw peat into a hard and densified fuel that will not crumble in burning. Peat fuel suitable for commercial purposes has not been produced hitherto without the use of complicated but expensive plant, to employ which for making the fuel in large quantities would neither be practical nor pay commercially. Nevertheless, inventors continue to pursue the old idea of using pressure to squeeze out the water, ignoring the fact that the use of pressure in any form will never produce a fuel from peat in such a hard and dense condition as will enable it to compete successfully with coal.

In an interesting process invented by Sir Edward Zohrab, Bt., this difficulty, however, appears to have been overcome; not only is pressure not used, but no expensive machinery is required. The process may be briefly described as follows:

The raw peat, when taken from the bog, is placed in a mill, which not only pulps and moulds it into blocks or briquettes of any desired size or shape, but so thoroughly and effectually desiccates the fuel that all the fibres or tubes which permeate the peat and are filled with water are completely cut to pieces. These fibres or tubes, if not perfectly destroyed, continue to hold water, which is converted into steam in the drying process, thus preventing the peat from becoming a perfectly homogeneous and dense fuel. No compression whatever is used, and to attempt to produce a satisfactory peat fuel by pressure would apear to be foredoomed to failure, since no matter how much the peat is pressed, the fibres, if not completely broken down, resume their natural size as soon as the pressure is withdrawn, again filling with the moisture remaining in the peat, thus causing the blocks to crack and crumble.

From these special mills the blocks of peat are conveyed on traveling bands to the drying machine, from which in a few hours it emerges in a very hard and densified form, containing, according to a typical analysis, only 15.5 per cent of moisture, and having a specific gravity of 1.29. It would seem that in this form peat should possess a future as a coal substitute, provided that the selling price was right.

Apart from the use of densified peat as an ordinary fuel in circumstances where coal is now consumed, it is when the peat is converted into charcoal—or perhaps we should term it peat-coke, judging from an analysis which shows figures closely resembling, but somewhat better than those for good quality Durham coke—that its uses should be most extensive. In the iron and steel industries there are obvious possibilities. It is claimed that it can be successfully used, not only to produce charcoal iron, but also in the blast furnace on account of its hard, homogeneous character, this enabling it to stand the burden of ore which would cause ordinary peat fuel to crumble to powder.

As a fuel for locomotives densified peat has been tried with success. The first test was on a goods train weighing 145 tons, the locomotive weight being fifty-six tons. The fuel placed in the tender was a mixture of densified peat and Scotch coal in the proportion of 9 cwt. to 3 cwt. The length of the test run was thirty-eight miles, part of the distance being up a heavy grade. The amount of fuel used was 10 cwt. 1 qr. 6 lb., equal to 30.4 lb. per mile. The second test was made on an express train running between Glasgow and Dundee and back, a distance of 180 miles. The fuel was one-third Scotch coal of a poor quality and two-thirds densified peat. The fuel consumption was at the rate of 31.4 lb. per mile. The average consumption of coal on the railways on which the trials were made was 44 lb. per mile.

Each ton of the densified peat produces 8 cwt. of charcoal, as well as large quantities of valuable by-products, including sulphate of ammonia, alcohol, acetic acid, phenols, and oils. Besides these, large quantities of gas are evolved, this being a mixture containing about 10 per cent. hydrogen, 11.5 per cent. menthane, 3.4 per cent. ethylene, 14.4 per cent. carbon di-oxide. The amount of gas given off from one ton of densified peat is stated to be 14,000 cubic feet. Some of the gas thus produced is employed in connection with the drying machines, and is used as part of the blast in the iron furnaces, thereby augmenting the heat and economising the solid fuel required.

It would certainly seem, in view of these claims, that the time is ripe for another attempt to be made to use successfully the vast deposits of peat contained in these islands. If this could be done, then we should have another source from which to obtain our light, heat and power; mineral deposits now undeveloped in consequence of the coal's being too far distant to enable them to be worked could be utilized; a high grade of iron could be produced from our own ores; we should have a smokeless fuel; and, lastly, our coal deposits would be conserved to a very considerable extent.—*London Daily Telegraph.*

Variation of the Size of Drops

When a drop is detached from a capillary orifice, the perimeter of the section of rupture is considerably less than that of the orifice, and the surface tension calculated according to Tate's law is much too small. It is usually assumed that the weight of the drops is independent of their frequency, whereas actually this weight shows a continual variation, which may exceed a quarter of the total weight. The results of the author's measurements show that the weight of the drop is at first sensibly constant and that it begins to increase as soon as the frequency surpasses 15 per minute. The increase is initially rapid but later proceeds more slowly until at a frequency of 100 the weight passes through a maximum. As the frequency increases continuously, the weight of the drop exhibits three further maxima, each greater than the preceding, and subsequently appears to diminish continuously. It is evident that, when the increased frequency causes the diminution of the volume of the drop to exceed a certain limit, the drop assumes a different form, passage from one form to the other being in general sudden.—P. Vaillant in *Comptes Rendus.*

Thorium Lead

Assuming ThE to be the final, non-active product of thorium and an isotope of lead, the atomic weight of ThE should be 208.1. As all thorium minerals contain uranium, however, the separation of the RaG (at wt. 206) from the ThE would hardly be possible. From a study of thorite from Ceylon and density measurements Soddy [see *Science Abstracts*, 502 (1915)] deduced the at. wt. of thorite lead as 207.74. [The author gives this value instead of 207.64 as stated by Soddy, and 207.2 for lead; in 1914 the value 207.1 was still the internationally accepted value.] Using Soddy's original material, the author determined the atomic weight for thorium lead directly by distilling the chloride and determining the ratios $PbCl_2{:}2Ag$, and $PbCl_2{:}2AgCl$, after the method of T. W. Richards; the result, 207.77, agrees well with that of Soddy [see also Abs. 310 (1917)]. Lead from thorite poor in uranium seems certainly to have a higher atomic weight than common lead. From the periods of thorium and uranium the author further estimates that RaG and ThE should be present in thorite in the ratio 10:90; that estimate would lead to the atomic weight 207.9 for ThE.—Note in *Science Abstracts* on a paper by O. Hönigschmid in *Phys. Zeits.*

Destroying the Crow and His Cousins

Birds that Consume Valuable Grain Supplies

Now that the world is faced with a serious shortage of food, and that the price of seed-corn is soaring beyond bounds at the very time it is needed most, it behooves us all to discriminate sharply between those birds that are insectivorous and therefore the friends of man and his crops, and those that are graminivorous and hence peculiarly inimical to human interests. Among the latter the family of *corvidae*, the crow and his cousins—ravens, rooks, magpies, jackdaws, etc.—are adjudged to stand, despite the fact that their diet is more or less omnivorous.

Their depredations in grain fields at the time of sowing, are, in fact, so serious that in France the Secretary

1. Great Raven. 2. Black Crow

of Agriculture has issued bulletins to the various prefects, signalizing the danger from this source, recommending the destruction of these birds, and offering information to this end.

This has instigated the following timely article upon the subject in *Larousse Mensuel* (Paris), which we believe will be of like interest in this country:

Under the general name of *corvidae* naturalists include various *passerinae Deutuostre*. The principal species of these living in our part of the country are: the great raven, the black crow, the hooded crow, the rook, the jackdaw, the magpie and the jay.

The great raven type of the genus, is a bird of rather large size, 0.70 meters, with powerful wings, enabling it to make lofty flights. Its manners relegate it to the lowest rank of the birds of prey; its voracity for the vilest carrion, its sinister plumage, its lugubrious cry, its wild aspect, the fetid odor it exhales, have at all times caused it to be regarded as an object of aversion.

In our part of the world ravens (corbeaux) are not birds of passage; they live by preference in small groups in rocky places, where they shelter their nests, descending to the plains only for food. The alimentary canal causes them to be classified among the birds which are both carnivorous and graminivorous; they feed on meat, in fact, attacking small animals, but also on occasion, eat grain, which they know how to unearth. They are thoroughly omnivorous and their food is very varied, ranging through dead mammals, birds, reptiles, frogs, molluscs, grain and fruits. Their utility is highly disputable; for, if their love of carrion gives them a value as scavengers in countries of rudimentary hygiene, it is not so in our land, where they are justly reproached with the destruction of settings of game birds.

The black crow, *corvus corone*, of smaller size, 0.50 meters is closely related to the former; its carnivorous instincts are also strongly developed. Living in the winter in numerous flocks with the other species, the crows invade the fields, keeping close to the ground and venturing almost under the feet of the farmers; at night they take refuge in trees; they thus inhabit the countryside until the heat obliges them to seek the coolness of the woods. At this time they separate and live preferably in couples. They keep an eye out for nests of eggs, as well on the farm as in game preserves; they pillage nests, devouring eggs and even young birds. One observer in the forest of Rambouillet, counted 45 broken pheasants' eggs at the foot of a tree where a couple of crows nested. The destruction of a few field mice is far from making amends for such depredations.

The hooded crow (*corneille mantelé*), or *corvus cinereus*, is distinguished from the preceding by a zone of slate-colored feathers forming a sort of mantle or ruff above the rest of his somber livery. This bird is entirely migratory. Living in numerous flocks it arrives in this country (France) towards the end of autumn, returning to the north in the spring. Like the preceding it is omnivorous with a preference for grains.

The rook (*corbean freux* or *frayqnnse*), termed in Latin *corvus frugilegus*, of size intermediate between the great raven and the crow, is distinguished by a beak denuded at its base, a characteristic produced by its habit of digging up the surface of the soil. It is essentially graminivorous, with an ample digestive apparatus, feeding, to the exclusion of meat, on grain and insects. It is migratory, and arrives at the beginning of winter in considerable flocks, with the hooded crows. It nests in colonies in the vicinity of settlements, forming noisy and disagreeable neighbors.

It is against these two species particularly, the hooded crows and the rooks, that the ministerial circulars are directed because of their disastrous ravages of the fields at seed-time and harvest.

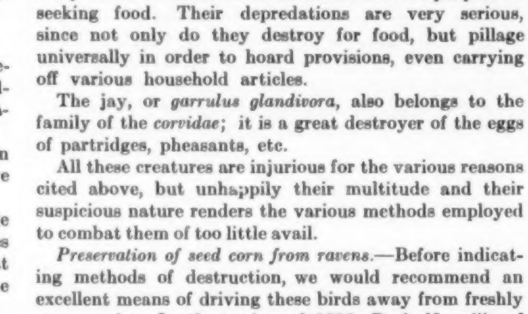
The jackdaw, *corvus monedula*, is the smallest of the crows, 0.38 meters; its habits are intermediate between those of the black crow and of the rooks. Though living on grain and insects, it delights to pillage partridge nests. Living in flocks, it likes to establish itself in ruined buildings; not very migratory, it prefers to take refuge in the summer in the forests.

The magpie, *pica candata*, is, like the raven, to which it is very analogous, omnivorous, feeding on eggs as well as grain and fruit; it even attacks young birds. Less well provided for flight than the ravens proper, it is rather sedentary. Magpies generally live in solitary couples. They unite to form flocks in winter for the purpose of seeking food. Their depredations are very serious, since not only do they destroy for food, but pillage universally in order to hoard provisions, even carrying off various household articles.

The jay, or *garrulus glandivora*, also belongs to the family of the *corvidae*; it is a great destroyer of the eggs of partridges, pheasants, etc.

All these creatures are injurious for the various reasons cited above, but unhappily their multitude and their suspicious nature renders the various methods employed to combat them of too little avail.

Preservation of seed corn from ravens.—Before indicating methods of destruction, we would recommend an excellent means of driving these birds away from freshly sown grain. In the spring of 1896, Prof. Neuville of the Practical School of Agriculture at Le Neubourg



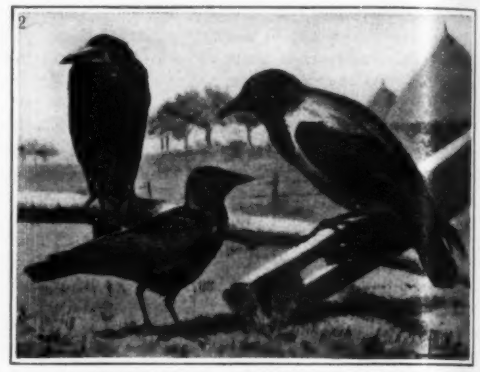
1. Magpie. 2. Jay

(Eure), proved that seeds soaked in certain substances lost nothing of their germinating power, while becoming repellent to ravens.

In 3 liters of hot water mix 200 grams of coal-tar (goudron de gaz) diluted with 200 grams of gasoline or petroleum. This amount will suffice to treat one hectoliter of seed-corn. If 200 grams of copper sulphate be added to the same mixture, the grain will be efficaciously protected from cryptogamic diseases. Certain grains as oats, can even support a double quantity of coal-tar and of the gasoline 400 grams of each, without losing the power to germinate.

Destruction of corvidae.—The numerous methods of destruction advised to destroy these pests that visit the fields in clouds, intimate the lack of efficacy of arms. The gun is one of the best, however, both because of the number destroyed and of the fear inspired in the rest. Where the birds take refuge in woods and shrubbery of the vicinity the "ambush of the hut" is recommended. At the edge of a wood or near a hedge a cabin built of branches is erected where the gunner can lie in wait and destroy the birds without rousing their suspicions. In open country it is very hard to come near them with fire-arms, for each band has a sentinel, always on the watch, giving a warning croak at the first sign of anything suspicious.

Ravens, magpies, etc., can be attracted by taking advantage of the hate they have for nocturnal birds of prey, which causes them to attack these when they meet them by day, defenseless because blinded by the light. The stratagem is called the "ruse of the grand duke." Near an ambush cabin one of these nocturnal prowlers is placed on a perch, either living or dead; by means of a cord the operator is able to make it move,



1. Hooded Crow. 2. Rook. 3. Jackdaw

while at the same time he imitates its cry by a bird-call. The *corvidae*, seeing their enemy, rush upon him, seeking to strike him with their beaks and to pick out his eyes. Thus they are themselves delivered to the gunner. (Vide Lar-Meno. vol. ii, p. 86).

Traps are employed with success. These most often take the shape of frames with nets attached, released by a bell-spring. The bird is caught when it sets off the spring by lighting upon it in seeking to reach the bait placed in the middle of the trap. In the winter this bait is a bit of carrion, a disemboweled rabbit with its entrails exposed; when nesting season begins, a nestful of eggs is used. To assume success many precautions are requisite. Care must be taken not to arouse the distrust natural to the birds. The trap must be rubbed with fragrant herbs, or placed on a dung-heap for a few hours, then put in position with tongs. The same method is pursued with the bait. Moreover, the frame and the spring must be disguised as well as possible with herbs. To make this easier traps painted green can be bought. The traps are then placed in the ground or on a post, and carefully surrounded with a barrier of twigs, to force the bird to light on the trap itself in order to seize the bait.

One of the methods of trapping these birds consists in paper cones of bird-lime. "Cornucopias" or "fool's caps" of stout paper, having the wide end about 4 or 5 centimeters in diameter, and about 10 centimeters long, and lined with bird-lime, especially at the top, are stuck into the ground and baited with anything attractive, meat, grain, beans, cracked nuts, etc. The voracious birds seize the bait greedily and the bird-lime instantly causes the paper cone to cling to the beak and cover the head, thus blinding them. Terrified, the creature at once rises almost vertically to a great height, makes a few turns, but soon falls exhausted, within a narrow radius. It is then easy to kill it with a stick.

The bird-lime employed is a very sticky substance, extracted from various plants such as mistletoe, viburnium and holly, that from holly being most esteemed. To make it, the exterior part of the bark of the holly is removed, the remainder is pounded in a mortar, and the resulting paste is boiled in water. It is then allowed to ferment, and thus is formed an exceedingly viscous substance known as bird-lime, which is purified by long-continued washing with water. A lime of poorer quality, but more economical, can be made by the lengthy boiling of linseed oil in a covered vessel; when shaken the resulting mass gradually assumes a viscous consistency. In order to handle paper cones or pieces of wood smeared with bird-lime without annoyance, it is only necessary to previously oil the hands, which prevents the lime from sticking to them.

Bird-lime was formerly much employed by hunters making use of a bird-call, a method now prohibited, because of the considerable destruction of useful birds

Hunting corvidae with the "Grand Duke snare"

it entails; however it produces results in the case of crows and magpies. The hunter places sticks covered with lime in the tops of trees, then, himself carefully hidden in a leafy bower at the foot of the tree imitates with a bird-call the cry of the common brown owl. The *corvidae* are at once attracted by the voice of the enemy, fly to the tree and are limed and caught.

Poison also may be used as the agent of destruction, but this involves great danger for domestic animals. When this method is used grain is steeped in decoctions of *nux vomica*, which contains strychnine, or else are coated with flour containing arsenic. Such grain must now be tinted green, blue, or black, according to a decree passed September 14, 1916, in order to lessen the danger.

In small gardens, etc., the birds are caught like fish, by hook and line, baited with beans or angleworms; they are then killed with a club.

Destruction of nests.—Finally, as prescribed in the law of July 23, 1907, a search is made for nests, especially from April to June. It is a principle that the eggs must not be destroyed until the mother is killed; for this reason the hunter remains in ambush until she returns to the nest and then shoots to kill. If the eggs are destroyed first the mother will not return to the nest, but will build elsewhere and lay more eggs, and since by this time the season will be more advanced, the heavier foliage may prevent the finding of the new nest.

Collective destruction by administrative measures.—When the raids of the *corvidae* are very serious, and these winged pirates fall upon our fields in legions, the isolated efforts of a few hunters are not sufficient to save the crops from their ravages. The mayors, authorized by prefectorial decrees, should then prescribe a general destruction of birds and nests in the territory of their communes. Guns, snares, all means, become lawful, and they may even stimulate the activities of the hunters by the offer of prizes. If these measures are still not sufficient it is the duty of the mayors to organize *battues* or slaughters throughout the whole region of the commune, obliging, if need be, hostile or refractory proprietors to allow these necessary destructions. These *battues*, supplemented by the chase in the forests under the direction of guards, will permit us to save a part of our crops from the voracity of these birds.

Soap Treatment For Infected Wounds

[Editorial Note—One of the notable results of the war and one which will redound to the benefit of humanity in the days of peace as well as now, is the great improvement in the treatment of infected wounds. Since competent authorities declare that not less than 90 per cent. of wounds received in war are infected, it is obvious that the aseptic treatment which is sufficient for so-called "surgical" or operative wounds, in hospitals, is insufficient. The most notable method of treating infected wounds is the Carrel-Dakin process, in which Drs. Carrel and Dakin have just been commissioned to instruct the military surgeons of America. This, however, requires a special technique and constant attention, hence the following report of an elaborate investigation as to the results of treatment by simple soap solutions is of wide interest, because of the universal availability of soap, the simplicity of its application, and its low price. The report, as made by Dr. Ratynski and presented on March 19, 1917, to the Academy of Sciences in Paris is as follows:]

Since the 16th of May, 1916, we have employed preparations of soap in the methodical treatment of infected wounds by means of detersive solutions used for washing the wounds and by bandages made porous by saturation with soapsuds.

Extensive burns, complicated fractures, large areas torn, crushed, bruised or tortuously shattered, open arthrites, amputations, resections and operatory results of the removal of injured portions have all been treated in our service by means of soap irrigations and soap dressings. The results may be thus summarized:

1. The lowering of hyperthermy.
2. Detersion in from 4 to 6 days equal to the best operatory toilet.
3. An immediate soothing of pain from the time the first applications are made.
4. Finally, the disappearance of swelling, lymphangitis, and inflammatory reactions of the periphery. The wound begins to take on an aspect of health and cicatrization and healing follows rapidly.

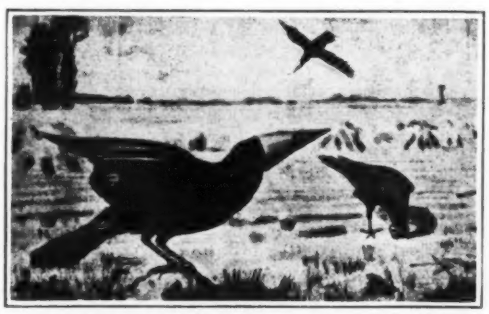
II.

A study of the antiseptic properties of soap has been often made, but the conclusions have been imperfect and unsatisfactory, since the authors of such investigations have usually failed to give the chemical composition of the soap, which is an important factor and which varies considerably in different makes.

Koch thought he had demonstrated that if soap was highly bactericidal for the germ of anthrax it was powerless against typhic bacilli and cholera. This view was partially confirmed by Di Mattee and partially combatted by Nyland and Max Iolles.

Behren, Reythoffer and Riodet have all made a study of the effect of soap upon the bacillus coli and the

1. Net trap attached to a tree. 2. Trap set on a post



Rooks caught with paper cones smeared with bird-lime

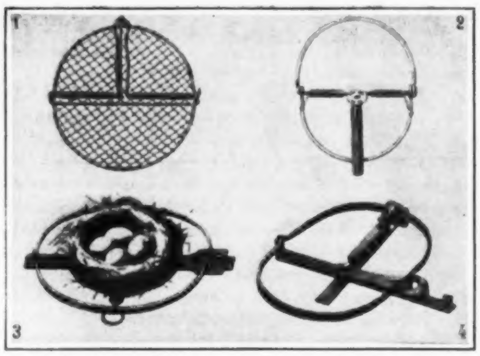
staphylococci, and have determined the duration of the power of resistance of these various bacilli, which is found to be dependent upon the chemical composition, the degree of concentration of the soap solution, and most of all upon the amount of alkali contained. The general conclusion is that soap has a very feeble bactericidal power upon the germs in which we are here interested.

III.

The discharges from wounds received in war, after they have been washed and irrigated and the compresses used in dressing them, are found to be rich in the number of germs contained, but poor in the variety of species. We have rarely been able to isolate the coli or staphylococci, and have found the proteins very exceptionally. The pyocyanic bacilli, on the contrary, were always present in marked predominance, and at times exclusively, especially at the very surface.

We have investigated the soap solution employed by us both as a culture medium and as a bactericide. The solution in itself is sterile and remains sterile. Upon sowing it with B. Coli, with staph. amens, with typhic bacilli, with pyocyanic bacilli, with proteus, or with ordinary pus, the cultures appear in more or less abundance. The microorganisms found in Seine water do not grow and neither do staphylococci.

Hence we consider the bactericidal power of our soap solution to be very feeble or approximately nil for pyogenic germs. It is not exerted appreciably except upon fragile microbes like the staphylococcus or



1. Spring trap with net. 2. Trap made of steel wire 3. With bait carrier. 4. Steel trap painted black

in mediums containing very few germs in a widely dissociated state, as in Seine water.

IV.

However, this absence of antiseptic power presents no inconveniences in a clinical sense, so far as the cure of wounds is concerned, since they heal rapidly without developing any septic phenomena.

There are in war-wounds two sources whereby the organism may be poisoned; the proliferation of septic germs and the putrefaction of tissues which have suffered lesions. The real danger comes from the wound itself, far more even than from the micro-organism which inhabits it. This danger being recognized and laid bare, the efforts of the surgeon must be directed towards combatting it.

V.

It is necessary, therefore, to thoroughly cleanse the wound even more than to disinfect or sterilize it, and above all to free it from putrefied debris, its albumens which have been attacked by necrobiosis and which poison the organism by their products (cenotoxia of Weinberg).

Moreover, these products offer the best conditions for protection and proliferation to bacteria. All the resources of therapeutics must be bent towards this object: to stimulate lysis, the destruction and elimination of necrobiotic products, rather than a furious attack on microbes. This conception enables us to comprehend the utility of a therapeutic agent which is able, by its physico-chemical action, to attack, dissociate, disaggregate, or destroy decomposed albumens. The alkaline solutions respond to these desiderata; the chemical results which we have obtained by the use of soapy solutions have convinced us that they possess incomparable properties of detersion.

Thanks to M. Boujean, chief chemist of the laboratory and member of the Consul Supérieur d'Hygiene, we have been able to determine that our solutions do not irritate nor attack living tissues, that they are sycophylactic; that they do not coagulate the blood, that they dissolve and liquefy clots, that they dissociate the debris of tissues which are sphacelated, even hardened, and finally that they form with pus a ropy, glairy viscosity.

All these circumstances explain the mechanism of elimination by means of lavings with soap solution. But there is involved also, as we have confirmed by experiment, a phenomenon of dialysis; soap, in the presence of healthy tissues, or in congestive reaction, exercises an attraction upon the salt of the serum of the blood and thus establishes an exosmotic current, a sort of drainage from the inside to the outside, of humors, which, besides the mechanical action which they exert, probably possess some bactericidal properties.

Finally, experiment has demonstrated that under the inflence of the carbon dioxide of the body, emanating from the congested peripheric area, in intimate contact with the tissues of the wound, the fatty matters of the soap are set free in the colloidal state, and contribute to the detersive action of the soap and also act as a sedative to the pain.

VI.

In various memoirs we have given information as to the chemical composition of the soaps whose use gives the best results, the methods employed for preparing aseptic solutions, the description of the soapy compresses used for bandages, the technique of the method, the description of the experiments, and finally, the principal observations we have made in connection with the matter.

The simplicity of the whole technique and of the method itself, which is one of the prime conditions of success, partly explains the excellent results obtained.

Commercial Alloy Steels*

Historical and Practical Notes on their Development and Use

By Edgar D. Rogers[1]

THIS subject covers such a wide scope that it seems advisable to limit this paper to a more or less historical and practical viewpoint regarding the development and use commercially of alloy steels, rather than to attempt a thesis on the technology of the subject, except in a most superficial way. No attempt has been made to cover the field of strictly crucible steels.

The oldest alloy steels of which we can find record are an ingot of prehistoric times, analyzing 1.20 per cent carbon, 1.60 per cent silicon, unearthed near Nancy, and a tool containing a small percentage of nickel, removed in 1837 from the Cheops Pyramid. Also the Damascus steel of Toledo contained tungsten, nickel and manganese. There is no evidence that these steels were intentionally alloyed, but were the result, probably, of a combination of different element-bearing ores. During the eighteenth century great advances were made in metallurgy, although the opinions on the subject were vague. The effects of phosphorus, sulphur, bismuth, tin, antimony and arsenic in iron were known about 1740.

It was not, however, until the first half of the nineteenth century, and then only after ordinary carbon steel composition had been determined by Reaumur, that the first intentional experiments to alloy metals with iron were undertaken. In 1812 Hassenfratz, under orders from Napoleon, completed his work on the effects of cobalt on iron. The effects of titanium, chromium and tungsten were also known about this time.

SILICON AND MANGANESE

Knowledge of silicon and manganese as alloys was limited up to 1880, although Gautier in 1876 had made observations regarding the hardening properties of manganese. R. H. Hadfield in the year 1880 began probably the first thorough research in the metallurgy of steel regarding silicon and manganese. As a result he published works of vital importance for the development of steel with these elements. Hadfield justly designates the year 1888 as the beginning of a thorough knowledge of alloy steels, when quite a number of such steels were produced in large tonnage and the use of silicon and manganese for the improvement of the physical and magnetic qualities was made practical.

CHROMIUM AND NICKEL STEELS

The founder of the chromium steel industry in America was Julius Baur of New York, who, after receiving letters patent for the manufacture of chrome steel, formed a company in 1869 which soon marketed its product with success. In Europe chrome steels were first produced by Holtzer & Co., Unieux, France. In 1870 they manufactured chrome steel armor-piercing shells and armor plate containing about two per cent chrome. Soon thereafter Hadfield began the manufacture of chrome steel in England, and in 1882 furnished chrome steel shells to the English Government which penetrated 8-inch wrought iron plates.

The development from this time on was quite rapid and chrome steel was introduced largely for safe work, jail work and other lines somewhat related to its original uses. The modern manufacture of this steel has broadened it beyond these uses and a large tonnage is now annually used by the ball and roller bearing industry. It is also used extensively in tool manufacturing lines and for other purposes where intense hardness is essential.

From 1822, when Stodart and Faraday at Sheffield published their experiments on the alloying of nickel and iron, up to 1885, when a pure ferronickel was brought out, nickel steel, on account of its expense, was not developed to any great extent. While during this period Wolf, Fairbairn, Therber, Bessemer, and others, carried on extensive and valuable investigations, contributing to the development of this steel, it nevertheless remained for James Riley, then of Glasgow, to demonstrate by practical tests the advantages of alloying nickel with steel. Mr. Riley's paper on this subject, read before the Iron and Steel Institute of Great Britain in 1889, gave an impetus to the introduction of nickel steel in a commercial way.

The advantages of nickel steel in ordnance led to its use in the manufacture of guns of heavy caliber. The fact that the propeller shafts of the gigantic double-screw express steamer Deutschland, launched in 1889, were made of nickel steel is evidence of the remarkable progress made in the manufacture of this steel and the recognized advantages in its use.

Nickel steel is now used extensively in automobile construction for parts such as frames, gears, shafts, and its utility in fields of structural fabrication, engine building, ship building, and many kindred lines too numerous to mention, is established and increasing.

VANADIUM IN STEEL

In 1803 Del Rio, professor of mineralogy in the City of Mexico, isolated this element and called it erythronium. However, it was not until 1830 that Sefstrom, a Swedish investigator, succeeded in attributing the superior properties of some of their soft irons to this wonderful element, and gave it its present name.

The manner of the use of vanadium and its effect became known no sooner than 1900 through Arnold, who demonstrated a method of using it in a commercial way. Further investigations as to the action of vanadium in steel have been carried on by Nicolardot, Guillet, Putz, and others. With its marked affinity for numerous elements it was found in minute contents combined with the various minerals universally.

Owing to its enormous cost, which in 1895 exceeded \$10,000 per lb., very little was done with it as a steel alloy, but a vast deposit was unearthed in South America in 1905 and its cost was thus soon brought within reach of the commercial consumer.

Its property as a scavenger in cleansing steel of its impurities other than phosphorus and sulphur, and the dynamic qualities, together with the superior static results obtained when used in conjunction with chrome, created a demand for this alloy which has been remarkable. The Swedish irons used as a base for high-grade crucible steels owe their virtues to this element. One of the first extensive uses synthetically, however, was in conjunction with high speed steels whose cutting properties were trebled and even quadrupled thereby.

The automobile, locomotive and high speed engines, with their demands for anti-fatigue material, opened a wide field for this product. It was this demand that caused the entry of the open-hearth and electric furnaces into the manufacture of this alloy steel.

About 1907 chrome-vanadium steel was first successfully made in the open-hearth furnace in commercial quantities. The consumption of vanadium as an alloy has steadily grown so that today it is used in combination with practically all other alloys, and in crucible, electric and open-hearth practice.

RECENT DEVELOPMENTS

The use of alloys in the manufacture of steel was effected in a commercial way about 1880. The demands of a steel to meet the use of more powerful explosives was the first influence toward the use of alloys and resulted in the introduction of nickel and chromium in steel for ordnance work. In their infancy these steels were made and alloyed in the crucible, and it was from the crucible mills with their ultra-expensive practice that the consumer obtained his supply. Later the demand increased so tremendously that the open-hearth and electric furnaces were drafted into service, the former turning out an excellent product at a very much decreased cost owing to the tonnage involved, and the latter rivaling the crucible for purity and with its costs also decreased as against the crucible practice. This was due to the charge of tons in the open-hearth and electric as against the crucible's charge in pounds.

During the past decade wonderful strides have been made in the development of alloy steels of high physical properties. Such developments were brought about largely by the severe and exacting requirements of automobile manufacturers, as with the introduction of motor vehicles it became necessary to economize in space and weight, and to meet these requirements metallurgists turned their attention to the development of steels of greater efficiency. This resulted in the adoption of practically standard analyses, by which small percentages of the standard alloying elements, vanadium, chromium, nickel, tungsten, etc., introduced into the metal increased its strength, toughness, hardness and other physical properties sufficiently to meet the exacting conditions. In addition to the alloy steels containing the above mentioned elements, another class was developed by adding abnormal quantities of the essential impurities, silicon, manganese, or both, either with or without the aforesaid alloying elements. The production of satisfactory manganese, silicon and silico-manganese steels is now commercial.

MACHINABILITY OF ALLOY STEELS

Some consumers specify alloy steels which must be made to analysis, heat treated to certain required physical results, and then either cold drawn or turned and polished, so that the consumer has only to use the steel as furnished by the steel manufacturer in its finished form. This demands of the steel maker not only heat-treating facilities but equipment for producing steel with the highest possible finish.

The problem which is now confronting the steel maker more and more is the machinability of steels capable of possessing high physical properties. Marvelous developments in tool steels, due to the improvement of the present-day high speed steels, has caused a proportionate increase in the efficiency of machine tools which means a "speeded up" production inconceivable ten years ago. I believe that the efficiency in improving machinable steels has not kept pace with the improvement in tool steels and machine tools. This is not entirely to be blamed upon the steel maker, as much steel is furnished in a green state, or the operations performed upon the steel before machining being thermal in nature destroy its production efficiency unless this structure is returned to its proper status. There is a large field for investigation as to the various mill operations to obtain a commercial practice which will deliver steel to the consumer in a uniformly machinable condition.

A few years ago, and even to date, a steel which was difficult to machine was "annealed." The peculiar characteristics of the steel were not investigated, but the steel was treated in a more or less superficial way and heated "somewhere in the neighborhood of 1500 deg. Fahr. and cooled in a slow heat conducting medium," which sufficed to obtain more or less uncertain results for the customer. Inasmuch as we are living in a day of special steels and each steel is indeed a deep study in itself, the problem of machinability becomes not that of a mere annealing (which in some cases is sufficient, however) but a scientific research of the metal through its many operations from ingot to bar. Casting, breaking down, rolling and principally finishing temperatures, all must be looked into with utmost care. These details must be not only ascertained but duplicated day in and day out in order to reach the ideal condition. Thus when each grade of steel is intentionally, and not more or less accidentally, made a consistent machining proposition, will the production which is sought be attained.

THE SPECIFICATIONS

The question of chemical and physical specifications is an important one to the steel maker. It has been the habit of consumers when buying their materials to specify both chemical and physical properties, and in a good many instances properties that are conflicting and inconsistent. It has been our experience, and no doubt that of all the other makers of steel, to receive orders on which certain chemical limits that are commercially possible are outlined, and then physical results demanded that are absolutely impossible with the prescribed analysis.

In some cases the ductility factors, elongation and reduction are specified at percentages that cannot be met with the high elastic limit required. In others the hardness (placed either at a maximum to obtain machining qualities, or at a minimum to assure the elastic limit's being up to specifications) is entirely inconsistent with the tensile strength and elastic limit. These discrepancies are in a good measure due to the steel makers themselves, because only a few years ago the data at hand on alloy steels were obtained through tests in which the type of steel was the only variable, little consideration being given to section when recommending a steel for a prescribed purpose.

A standard test piece which has been heat treated after machining, as we all know, will show percentages of elongation and reduction which cannot be obtained with a test piece machined from a heat-treated part of greater section. Also a treatment which will produce certain properties upon a test piece treated after machining will not suffice for the heavier section. Be-

*Republished from The *Iron Age*.

[1] Genl. Sales Manager United Steel Co., Canton, O.

cause of the inconsistency of imposing physical specifications based on a standard test specimen heat treated, as against a specimen cut from a larger section after heat treatment, steel manufacturers have often found difficulty in meeting the requirements demanded.

Physical specifications should be drawn up in accordance with the results which should be obtained from tests taken from the full section in question. Data are often given out by steel manufacturers as to physical properties of steel without specifying the section from which the tests are made, which is thereby misleading.

PROPER ELASTIC LIMIT

Again, concerns have been impressed with the virtues of some type of alloy steel by reason of its exceptionally high physical properties and assume for instance, that a steel which is stated to show 200,000 lb. per sq. in. elastic limit must necessarily be better than one which shows only 150,000 lb., ignoring entirely the purpose for which the steel is to be used. In reality the lower elastic with greater ductility may, for a particular purpose, serve to better advantage than the higher elastic and lower ductility, both results, however, being obtained from the same steel by different thermal manipulation.

The various types of alloy steel each have distinct properties for a constant elastic limit. The elastic limit is the working feature in all parts because after determining the stresses and by adding a factor of safety there is obtained a gross stress which must be resisted, and this resistance must in all cases be exceeded by the elastic limit. The type of steel then to be selected should be determined by the nature of the stresses and not the amount, for it is possible to obtain equal elastic limits in several of the alloy steels that are made today; for instance, where an alternating stress will cause a chrome-nickel steel to fail a chrome-vanadium steel will serve satisfactorily, even though it is treated to show no greater strength. This is due to its superior dynamic properties.

The consumer should, when specifying steel, arrive at the grade through the nature of the stresses, the elastic limit by the amount of the same, and be content with the tensile, reduction, hardness, etc., which that particular type of steel must necessarily possess with a certain elastic limit.

PROSPECTIVE

The manufacture of alloy steel tube stock has received great impetus in this country since the war began. In fact, many consumers in this country have learned that a high-grade product of alloy steels can be obtained from the American steel makers. Steels which were formerly purchased abroad are now being produced by American manufacturers with satisfactory results. Therefore, the American steel maker, as well as the maker of finished articles heretofore imported, can hope to retain this trade, it having been fully demonstrated that American steels are equal in quality to the foreign steels.

The railroads have been far less active in the adoption of alloy steels than the automobile manufacturers, though during the past few years there has been on their part a greater realization of the merits of alloy steels effecting greater safety when operating at high speeds. The saving in weight in construction is a factor that the railroads cannot well overlook, as during the past few years the trend has been tremendously to increase the size of locomotives. This cannot be done without a decided increase in weight unless an alloy steel is used.

The first obstacle in securing a more universal acceptance of alloy steel by the railroads has been the lack of preparedness on their part to properly heat treat. I wish to make myself clear on this point in particular, namely, that an alloy steel without heat treatment is but little better than a carbon steel, and in some cases more dangerous. Sound business principles should prompt the user to heat treat in order to obtain the maximum efficiency for which the consumer pays the additional cost for alloy above carbon steel. Proper heat treatment will in many alloy steels approximately double the static strength and will at the same time produce a higher degree of ductility. Railroad shops as a rule are woefuly lacking in proper equipment for heat treatment, and until they provide furnaces of close and uniform operation and control, dependable heat measuring apparatus, suitable quenching facilities and mechanical methods of handling the material, it will be impossible for them to realize to the fullest extent the degree of superiority of the alloy steels over the carbon steels.

The steel maker can furnish the axles, side rods, and other forgings, heat treated and rough turned, finished or ready for finishing, but he can only furnish such parts which are not in the course of manufacture subjected afterward to any hot work, and parts where no greater hardness than is consistent with good machining is essential. A proper heat-treating equipment would be of great service to the railroads also in the rebuilding or repairing their present rolling stock with durable alloy steels.

FUTURE OF ALLOY STEELS

I predict that the next few years will show a greatly increased demand for alloy steels from the manufacturers of railroad equipment, machine tools, engines, mining machinery, farm tractors, aeroplanes, etc. Alloy steels will also occupy a larger field in marine construction, particularly in submarine work.

The aeroplane manufacturers are already calling for the highest grade of electric furnace alloy steels. If we review the wonderful development of aeroplanes in the last few years we can readily get a better idea of the greater possibilities in the future.

The field for the development of the tractor engine offers one of the attractive American manufacturing possibilities. The successful development of tractor engines in a large measure will depend on the increased use of alloy steels so that the tractor may be lighter in weight and stronger in construction.

Many other manufacturers have up to this time overlooked the great possibilities in the use of alloy steels in their products. There is a wide field for development.

GENERAL CONCLUSIONS

The experience of alloy steel makers during the past seven years shows a steadily decreasing cost of production and a decreasing selling price due to many changes in manufacturing methods. Some mills which are now specializing in alloy steels have developed as the result of their experience methods of manufacture which are quite dissimilar in many phases to the manufacture of common steels. The waste product has been greatly reduced, this having been accomplished by the reclaiming of material which was formerly rejected. Heretofore the practice was to discard a very large percentage of the heat which resulted in high cost of production. Economical methods put into effect resulted in a higher quality of steel and a better practice. While chipping, grinding and reclamation of steel in other ways entail a higher cost per ton for the making of the steel, they have resulted in ultimate decreased cost and cleaner billets, producing not only a greater yield of bars but a finished material free from defects and imperfections. This is beneficial not only to the consumer but also to the manufacturer, who, by conscientiously cleaning his stock, is assured that the material will remain sold and give satisfaction.

Citing my company for example, rejections by the trade during the past seven years have declined very materially; that is, from 5 to 10 per cent. seven years ago until during the past few years average rejections have been less than one-half of 1 per cent.

Lower costs are due also to decerase in cost of some of the alloys, as, for instance ferrovanadium, and to lower cost of heat treating, because of the greater amount being treated, together with improved design in furnaces to facilitate handling the stock. Lower selling prices will generally result in the further expansion of tonnage.

THE ELECTRIC FURNACE

The perfection of the electric furnace for steel melting has enabled the manufacturer to duplicate by this method many steels which were formerly made in the crucible, and at a reduced cost. There is a large opportunity for introduction of such steels for use where the excessive cost of machining necessitates an absolute minimum of rejection, and which steels cannot be made successfully in the open-hearth furnace. This is especially applicable to parts where under rigid inspection minute defects cause rejections.

The advancement made in the manufacture of alloy steels in recent years is a tribute to the steel makers and speaks for the progress, the increased efficiency and years of hard work on the part of the steel manufacturer necessary to accomplish this result. From one point of view this remarkable efficiency of practice is a greater achievement than some of the metallurgical successes in the field of alloy steels. It is a homely story of human effort which is only fully appreciated by the steel manufacturer.

Eskimo Music

An Eskimo "fiddle" consists of a rude box, with a square hole in the top, three sinew strings with bridge and tail-piece, and a short bow with a whalebone strip for hair. It must be a rude imitation of "fiddles" seen on whaling ships, as the drum is the only indigenous musical instrument of the Eskimo. Most Eskimo fiddles have only one string. When I asked an Eskimo musician once about this he said, "One string is plenty for an Eskimo song." Anyone who understands the range of the Eskimo scale will appreciate the answer.

The Eskimo have a keen appreciation of music and not unpleasant voices, which have been turned to account by the Moravian missionaries. One is considerably surprised in stepping into a mission service to hear the Eskimo congregation singing their native hymns to Bach's grand old chorals, in perfect harmony and with deep feeling and evident emotion. The men have deep, rich bass voices, but some of the women's voices are rather shrill. Nathaniel, the choir leader at Nain, has composed an anthem in four parts, showing that the Eskimo are not incapable of constructive work in music. The Moravian Mission Eskimo also show an aptitude for civilized musical instruments, and there is a well-balanced band at both Nain and Okkak. The organist, Jeremias, at Nain, the Moravian headquarters, is a musician of no mean ability. He can play classical selections on the pipe organ and any band instrument. The Eskimo have a good ear for music, and will catch an air after it has been sung once or twice to them, and repeat it with great gusto and evident feeling for the rhythm. Rhythm is the foundation of their native drum and dance songs, and it is not so remarkable that they excel in it, as it is that they are able to catch the entirely foreign time of the complicated music of civilization.

The Eskimo music differs from civilized harmony in having a pentatonic scale, and in the constant reiteration of a note or phrase, particularly in their *a-ya-aya-ya* chorus. A drop of an octave or a shift into another key is not uncommon in the same song. The time is 2-4, formed on the double drum beat, which the voice accentuates in the music. The body, with odd jerking of the arms and stamping of the feet, answers the roll of the drums in the dance. The women stand with feet together and sway the body from the hips, and wave their hands. (In some sections, as in north Greenland, the men also stand with fixed feet while dancing and singing.)

The song is delivered at the top of the voice, the idea seeming to be that the more noise the better is the music. The men's songs are interspersed with shouts. The women have soft cradle-songs which they sing to the babies in the hood while they are swaying them to sleep. These are more melodious than the drum-songs. Among the Alaskan Eskimo the young girls have a curious type of song which they perform among themselves as a sort of game or amusement. It is called "throat-singing" and consists of a series of guttural ejaculations, which they attribute to the Raven. Incantations are chanted. In story-telling, a man often stops to sing a short phrase or song, as delivered by a character in the legend. As Mena'dlook, an Alaskan Eskimo once told me, "The Eskimo have many songs. They have songs to make the wind blow, songs to make the seals come, songs to dance by, songs for play, songs to keep off the spirits, songs to make their hearts strong." Songs are property among them, and the originators or old men who have learned appropriate songs sell them on ceremonial occasions.

Until they have been educated to it and understand the intricacies of modern music, Eskimos as a rule do not like civilized music. They say that there are too many notes, too much noise, that the time is confusing, and that they prefer the simple rhythm of their native songs. Of the "white man's songs," they like best the old-style hymns.—*Geological Survey, Canada Anthropological Series 14*, by E. W. Hawkes.

Chemical and Physiological Detection of Several Alkaloids

The characteristic reaction of strychnine with sulphuric acid and potassium bichromate is not shown by 1 mgrm. of strychnine nitrate in the presence of 0.04 grm. or more of quinine bisulphate, a transitory, granet-red coloration being produced, which becomes green or greenish-grey; with smaller quantities of quinine, the reaction is distinct, but transient. The same effect is observed when salts of the alkaloids with the same acid or the free alkaloids are used. Crystals of strychnine picrate can be obtained in the presence of a large excess of quinine, but they are not then characteristic. The alkaloids are most simply and certainly separated by the use of sodium potassium tartrate; quinine tartrate is insoluble in solutions of alkali sulphates and tartrates, whereas the strychnine salt is soluble. Mixtures which do not give the characteristic reaction with postassium bichromate do not cause the characteristic symptoms in the frog.—Note of an article by E. Philippi in *Arch. Farm Sperim.* in *Jour. Soc. Chem. Ind.*

Making Window Glass by Machinery*

A Review of the History of the Art, and of the Principles Involved

By Robert Linton[1]

THERE are two kinds of transparent sheet glass, termed commercially plate glass and window glass, manufactured by two radically different operations. In making the former, a quantity of molten glass is poured upon a casting table and rolled out in a sheet which is placed in a kiln where it is annealed and cooled. The sheet produced in this way is rough, as the metal table and roller, no matter how smooth, will leave an impression on the soft glass, consequently it has to be ground down to a plane surface on both sides and then polished in order to render the surface smooth and the sheet transparent. Window glass is made by blowing or drawing a cylinder in such manner that nothing but air comes in contact with the surfaces during the operation, cutting open the cylinder longitudinally, reheating it, and flattening it out in a sheet which is then annealed.

Glass blowing is an art that runs back into antiquity—no one knows how far. A book on glassmaking published in Leipsic in 1689 that I have in my library contains an interesting illustration of glass blowers at work in a factory of that period. A writer as long ago as the eleventh century has described in considerable detail the blowing of glass cylinders and their subsequent flattening into sheets, and there seems to be little doubt that cylinders were blown long before that time.

Prior to 1903 window glass was made entirely by hand, and there is still about 40 per cent of the production of this country manufactured by this method. A brief description may therefore be of interest and aid in making clear the difficulties involved in devising apparatus to do the work mechanically.

The tool used is the blower's pipe, about five feet long, with a mouth piece on one end, and on the other, the bell-shaped wrought iron "pipe head." The workmen are the blower, gatherer and snapper, or blower's helper, the three men constituting a "Shop." The gatherer starts the operation by dipping the glass which adheres and forms a small ball. He blows through pipe head, which has been previously heated, into the mouth of the pipe sufficiently to expel the soft glass from the interior and form a small bubble in the ball. The glass is then cooled to the proper stiffness, more glass gathered and the operation repeated until there is sufficient glass to yield a cylinder of the desired size. For an ordinary cylinder the gatherer usually gathers five times.

The lump, which is in a state of rather stiff plasticity, is then carried to the "blower's block," an iron mold set in water to keep it from becoming too hot, and lined with charcoal to prevent the glass from being marked by contact with the iron. By turning the ball in the block, blowing air into the lump through the pipe and drawing it up towards him, the blower so manipulates the operation as to form a pear-shaped ball, the upper part of which has the diameter and thickness of the cylinder to be produced, the bottom containing a thick mass of glass that has now become quite stiff. The ball is now reheated in a "blow furnace" and when soft enough, the blower swings it out in a "swing hole" alongside the blow furnace. The weight of the glass elongates the cylinder and the blower keeps it distended to proper diameter by intermittently blowing air into it through the pipe. The reheating and swinging out is repeated until the glass in the closed end of the cylinder is of the same thickness as the other parts. This closed end is now exposed to the heat of the blow furnace, the workman at the same time blowing into the pipe and keeping the air confined by holding his thumb over the mouth piece. The glass in the end softens, and the heat at the same time expands the air in the cylinder, which finally bursts out through the end. The open end is heated still further and swung out into the swing hole in such manner as to make it cylindrical to the end. The pipe is removed by touching a cold iron to the glass just below the pipe head, and the pear-shaped cap removed by stretching a thread of hot glass around the cylinder, allowing it to remain until a heated streak is formed, and touching this streak with a cold iron causes the cap to snap off. The cylinder is split by passing a hot iron back and forth through the cylinder to produce a similar line of heat and touching it at one end with a cold iron, which results in a straight crack from end to end.

The cracked open cylinder is then carried to a flattening oven. It is laid on an iron carriage and pushed into the oven, where it is heated, lifted with an iron tool from the carriage and laid on the flattening stone—a large, flat fire clay tile with a carefully levelled and highly polished surface. As the glass softens the cylinder is spread out and then rubbed down flat with a wooden block mounted on a light steel bar. The stone with the sheet lying on it is then moved out of the flattening compartment into a cooler one, the sheet is gradually cooled down and when it is sufficiently hardened, it is lifted by means of a fork with smooth steel tines and laid on a conveyor which carries it slowly out of the oven. This part of the oven, called the "lehr," is for the purpose of annealing the glass by cooling it slowly and gradually, for otherwise it would be too brittle for commercial use. The ordinary type of flattening oven has four flattening stones set on a circular table—the "wheel"—which is carried on a vertical shaft turned by hand from a bevel gear drive.

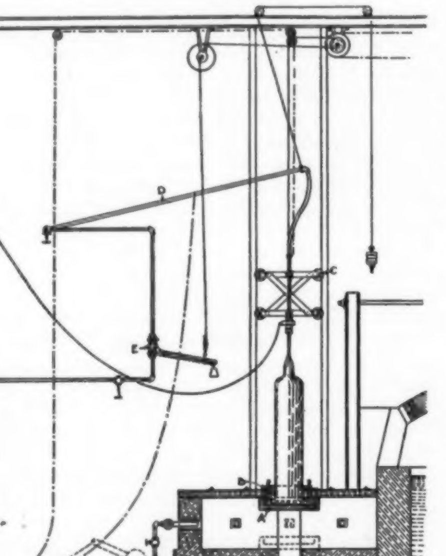


Fig. 1—Early type of Lubbers machine

It will be readily appreciated that blowing window glass requires unusual judgment and manual skill, as well as more than ordinary physical strength and endurance; also that the size and thickness of sheets that can be produced by hand is quite limited. In single strength (1/12 inch thick) the limit is about 14 inches diameter by 60 inches long; in double strength (⅛ inch thick) about 19 inches diameter by 70 inches long. The workers were extremely well paid. Blowers' wages ordinarily varied from about $150 to $250 per four weeks, and gatherers' from about $110 to $150. Blowers who made the largest sizes were paid much more than this; I remember one "big blower" in a factory with which I was connected who earned $642 in four weeks.

Window glass is a mixture of silicates of lime and soda. The raw materials are silica sand, limestone and salt cake (sulphate of soda) or soda ash (carbonate of soda). The mixture of these raw materials is called the "batch."

A characteristic analysis of window glass is as follows:

SiO_2	72.50
CaO	12.60
Na_2O	13.67
MgO	0.22
Al_2O_3 Fe_2O_3	1.01
Specific Gravity	2.52

Regenerative tank furnaces are now almost universally employed for window glass melting. A tank furnace consists of a long, rectangular hearth or "tank" constructed of massive fire clay blocks and kept filled with molten glass. The firing is through ports in side walls above the blocks, the flame sweeping across between the glass level and the crown from the end where the batch is filled in to a point usually slightly more than half way to the working end. The batch floats on the surface of the glass bath, exposed to the heat of the fire above and the molten glass below, and is gradually melted, refined and cooled to proper consistency as it is drawn down by the continuous working out of the glass at the other end. The temperature of the melting end is about 2,600° Fahr., and at the working end about 2,150-2,250° Fahr. in machine plants.

Glass does not have a definite melting point in the sense of a fixed temperature at which it passes from a solid to a liquid state. Strips of window glass under test have showed a slight deflection at 840° Fahr., while they lost stiffness at 920° and bent freely at 980°. The glass becomes softer as more heat is applied and becomes entirely liquid, so as to assume readily the shape of a vessel into which it is poured, at about 17,000°. With the application of still more heat the glass becomes of course more and more fluid until finally a point is reached where a slight decomposition and loss of alkali takes place, which manifests itself by bubbles of gas rising through the heated mass.

The viscosity of molten glass necessarily varies with the temperature, this being a natural law of liquids. Cohesion is strong, but weaker than force of adhesion to heated substances such as iron or clay. This gradual increase of viscosity with drop of temperature is an important factor in the manufacture of glass by blowing or drawing. The cooler the glass, the stronger is the cohesion of the molecules, and the greater will be the force required to draw the mass out, until at last the glass may become so stiff that the cylinder being drawn will not retain its form and becomes distorted and shapeless.

Liquid glass has a high surface tension at the temperature at which it is worked. In machine operations the glass is supplied to the pot or forehearth from which the cylinder is drawn hotter and therefore more fluid than is suitable for working. To bring it to the proper consistency, it is cooled by radiation and convection, either simply by exposure to the air, or by using a water chilled ring. The radiation of heat from the surface is much more rapid than the conduction of heat through the glass, and the result is a gradual cooling from the surface down, and a mass of glass with gradually decreasing viscosity from the surface down. In drawing a cylinder from such a bath of glass the portion outside the cylinder has a greater surface tension than the portion inside, as it is slightly cooler.

The important temperatures in window glass manufacture are the working temperature of the glass—about 1,500° in hand blowing and 1,750° in machine blowing—and the "setting temperature," or the temperature at which glass retains its form, which is about 850°. In the liquid state in which glass is worked in machine operations, it is so soft as to be extremely sensitive to changes in temperature or variations in exterior or interior pressure exerted at the point of draw.

When glass is cooled rapidly from the liquid or plastic state to the setting point, cooling strains develop between the surfaces and the interior of the walls of the cylinder. This is because glass in the solid state is extremely hard and non-compressible. In cooling, the surfaces harden first and the soft mass in the interior readily adjusts itself to their contraction; then the interior hardens, but as there can now be no further yielding of the hardened surface layers, the molecules are left in a condition of tension, and the more rapid the cooling, the higher the tension developed. This condition facilitates the capping-off and cracking open of the cylinders; it is to remove the strains and reduce the brittleness that glass is annealed.

Somewhere around 1896 John H. Lubbers, a window glass flattener by trade, began experimenting with a machine to make glass cylinders. He was a man of unusual natural ability and in working at his trade he had acquired a general practical knowledge of the physical properties of glass to which reference has been made above. He believed that he had devised a practicable method of drawing glass cylinders from a bath of molten glass, but being of limited means and realizing that considerable money would be required for his ex-

*A paper read before the Engineers' Society of Western Pennsylvania, and published in the proceedings of the Society. Vol. 33, No. 1, pp. 1-22, February, 1917.

[1]Consulting Mining Engineer.

periments he disclosed his proposed method to Mr. James A. Chambers, President of the Chambers Glass Company, in whose factory Lubbers was working, and one of the very ablest window glass manufacturers in this country. Mr. Chambers was much impressed with the practicability of Lubbers' proposed method, crude though the details must have been at that time, and advanced the necessary money to cover the cost of some preliminary experiments. Later a small company was formed, headed by Mr. Chambers, for the purpose of carrying out these experiments on a more extensive scale, for while Lubbers was actually making window glass cylinders, there were a great many difficulties still to be overcome in order to render his apparatus suitable for the manufacture of window glass in a commercial way. As a matter of fact it required years of work and an enormous amount of money to develop the apparatus to the point where it was finally operated at a profit. Nevertheless the machine of today still retains the basic features of the Lubbers' inventions, and considering how completely they revolutionized the established processes of window glass manufacture, Lubbers' ideas, as set forth in his various patents, show a surprising knowledge of the essential conditions for making glass cylinders by machinery.

The experiments were conducted in a small plant located in Allegheny, and it was here that the machine was operated that is shown in Fig. 1. There seems to be no doubt that this was the first machine that was ever successfully employed to make window glass cylinders.

The Lubbers process is a process for drawing cylinders vertically from a bath of molten glass. This in itself was not a new idea, as several patents—one dating back as far as 1854—proposed this. Lubbers, however, was the first to devise a workable method for really doing it, a process that took into account the peculiar conditions involved in working molten glass, and apparatus that actually made glass cylinders—cylinders that were in every respect similar to those that were blown by hand.

In the drawing *A* is a flat bottomed, circular pot placed in a heated kiln and movable vertically as shown by the dotted lines; *B* is a circular water cooled shield; *C* is a cross-head traveling on guides, raised by means of a cable winding on a cylindrical drum and carrying a detachable blow pipe of the general type used in hand blowing; *D* is a supply pipe for the admission of air under sufficient pressure to keep the cylinder distended to proper diameter; *E* is a graduating valve which is automatically opened as the cross-head *C* is raised, the valve being provided with a slotted opening of proper size and shape to admit the requisite quantity of air at each point of draw; *F* is a gasometer serving to maintain a constant pressure in the supply line conveying air to the graduating valve.

The operation was as follows: The pot *A* was raised to the top of the kiln and the water shield placed in the position shown. A quantity of glass sufficient for drawing one cylinder was ladled into the pot. A ball of glass was gathered on a blow pipe, the small bubble blown out as described above in connection with hand blowing, and the ball "marvered," or rolled on a smooth iron plate, so as to thin the bottom portion beneath the bell-shaped end of the pipe; the pipe was hung on the crosshead and lowered into the glass. The cross-head was then raised, air being admitted by the operation of the graduating valve, which swelled out the glass to the diameter of the cylinder to be drawn. The upward movement was then continued until the cylinder reached the desired length, the introduction of air being automatically regulated by the graduating valve. The cylinder was severed from the glass remaining in the pot in any one of several ways—either by dropping the pot and allowing the heat to melt the lower end, by shearing off, or by shutting off the air and continuing the upward movement, which contracted the lower end of the cylinder to a small cord which was sheared off. The pipe with cylinder attached was removed from the cross-head, lowered to a horizontal position, the pipe removed and the cylinder capped off as in hand blowing operations. The pot was lowered to the kiln to reheat it and melt to proper consistency the residue of glass that remained in it.

The control of the machine by the operator was at that time limited to stopping, starting or reversing the drum on which the cable wound that raised and lowered the cross-head, and in manipulating a hand valve on the air supply line between the gasometer and the graduating valve.

Cylinders were also drawn from a forehearth in the melting furnace itself. By this method the necessity of ladling was obviated, the glass flowing directly into portion of the furnace where it was sheltered from the heat sufficiently to give it the proper consistency for drawing.

The experiments were continued at Allegheny until the spring of 1902 when the factory of the American Window Glass Company at Alexandria, Indiana, was leased to Lubbers and the work was transferred there from Allegheny. There was a 54-blower continuous tank furnace at this plant, with all accessory flattening and other equipment for this capacity, and the machine installation was designed with a view to testing it out on a practical working scale, and to developing it as rapidly as possible to the point where it could be utilized in the plants of the American Window Glass Company. Material advancement was made, especially

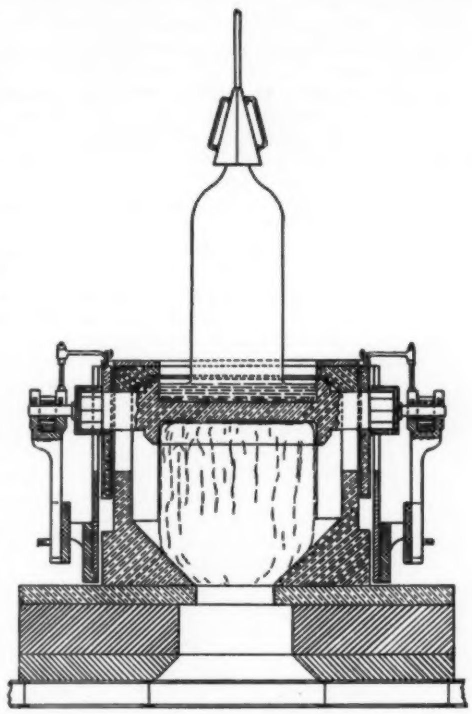


Fig. 2—Thornburg double-reversing pot and furnace

in the way of designing mechanical features, but the development of the machine to the point of making the necessary output, quality and cost was still far off.

However, nine of the largest factories of the American Window Glass Company were equipped with machines the following year. The company had been experiencing a serious and constantly growing shortage of blowers, due to the fact that there was a limited number of these skilled men in the country and because the plant capacity of the country had been rapidly expanding. Many independent companies, operating at a low fuel cost, offered high guarantees in wages to good blowers, and many blowers had organized co-operative companies. So that very strong reasons existed for

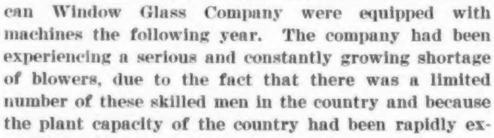


Fig. 3—Drawing cylinder from molten glass

pushing as rapidly as possible the development of the machine process, and it no doubt seemed reasonable to assume that this development would be very much hastened, if the machines were installed in these plants, manned as they were with the most efficient operating organization of the company. With such a force of practical glass makers giving thought and effort to the problems, it would naturally be expected that the difficulties that stood in the way of success would be overcome in the shortest possible time.

As a matter of fact, however, they proved more serious than was appreciated, and the work of developing and improving the various parts of the apparatus continued for about two years longer, before satisfactory results began to be obtained.

The record of the work done in these years of experimenting and development is a most interesting story, but it would be beyond the scope of this paper to give more than a very general account of it. Out of the crude apparatus shown in Fig. 1 was perfected a machine that is producing today results far beyond the most optimistic expectations of its inventor. One by one the causes of the troubles were located and the apparatus modified or adjusted to correct them.

That this work was so slow and so difficult was largely due to two facts which have been mentioned above, viz: First, that in the liquid state in which glass is worked in machine operations, it is so soft as to be extremely sensitive to changes in temperature or variations in exterior or interior pressure exerted at the point of draw; and second, that in working glass, cooling strains develop as the glass passes from the liquid to the solid state, causing brittleness.

The work may be divided into five general heads:

1. Adjusting the character and temperature of the glass bath to the requirements of drawing operations.
2. Increasing the size of the cylinders.
3. Closer regulation of the air supplied to the interior of the cylinder.
4. Better regulation of the drawing speed.
5. Handling the cylinder after completing the draw.

Adjusting the character and temperature of the glass bath to the requirements of drawing operations: The method of reheating the residue remaining in the pot after drawing a cylinder and then ladling fresh glass into the pot was not very satisfactory. It was difficult to get good quality of glass, for unless the glass in the pot and that which was ladled into it were heated to the same temperature and brought to a very fluid condition, they would not mix properly, and thus produce streaks in the cylinder. Similar difficulty was experienced in melting back the residues in the forehearth; if the glass was heated hot enough and skimmed when necessary in the manner employed in skimming the gatherers' rings in hand operation, the quality was satisfactory, but the operation was very slow.

It was then proposed to drain the pot between draws, and to accomplish this a furnace was built with four pots mounted on a turn table and so arranged that each pot would be tilted at a certain point. In this way there would always be one pot used for drawing cylinders while the others would be heating and draining. An improvement on this apparatus was the double reversible pot mounted on trunnions shown in Fig. 2 (invented by L. A. Thornburg) in using which one side was always being drained while a cylinder was being drawn from the glass in the other. When the Gas City plant was equipped it was necessary to decide which of the three forms of apparatus would be adopted, and the Thornburg reversible pot was chosen as being best suited to the operations as they were conducted at that time. It is still used by the American Window Glass Company and it is doubtful if any other form of receptacle for the molten glass can equal it for high output and economical operation.

It was also discovered that there was gradual cooling of the glass during the draw, and that it was important to control this so as to prevent one side from cooling more rapidly than the other as far as could be done. The effect of inequalities in the temperature of the bath is to produce "thick and thin" glass, i. e., that portion of the circumference of the cylinder where the glass is coolest at the point of draw will always be the thickest; also in many cases this inequality in temperature causes the cylinder to travel towards one side of the pot instead of continuing to draw vertically from the starting position. A great deal of difficulty was experienced in eliminating this "thick and thin" glass, as it could be due to a number of causes. More positive adjustment of the machinery, an improved type of ladle and method of ladling the glass from the tanks to the pots, more care in keeping the pots uniformly heated, and shielding the glass bath from draughts, very greatly reduced the proportion of "thick and thin" glass produced. It was, however, found so difficult to maintain absolute uniformity in the temperature and rate of cooling of the bath, that the practice was finally adopted of drawing from the center of average viscosity instead of from the center of the pot. In other words, when the glass in a place is thick and thin, and the apparatus is in proper condition, the blow pipe is simply moved sufficiently to bring the thickness uniform or practically so for the entire circumference of the cylinder.

It was thought in the early days of machine operations that some change in the chemical composition of the glass, or in the character of the materials from which it was made, would be necessary in order to adapt it to the new working conditions. The cylinder

was now being drawn from glass in a liquid condition, while the hand blower manipulated a lump sufficiently stiff to be retained on the end of the blow pipe. The glass was worked out of the tank much more rapidly, which accelerated the flow proportionately. Considerable experimenting was done with various mixtures and various kinds of materials, but in the end it was found that the chemical composition that gave the best glass under hand operations was also the best for machine operations. The increased draw on the tanks necessitated, however, alterations in the melting furnaces and the tanks of the American Window Glass Company so remodeled have yielded quite remarkable results. The maximum amount of glass gathered in 24 hours from one of these, under hand operations, was 3.7 per cent of the total contents of the tank, while under machine operations more than 20 per cent has been ladled from the same tank in 24 hours.

Increasing the size of the cylinders: The original Lubbers machine, as has been above stated, made a cylinder about the size of a hand-blown cylinder. It soon became obvious that production could be very materially increased by ladling a larger quantity of glass into the pot, and drawing a longer cylinder, which could be cut up, after lowering, into lengths suitable for flattening. This introduced complications in the control of drawing speed and air supply which will be discussed farther on, but eventually the point was reached where five flattening lengths about 14 inches in diameter by 60 inches long could be produced at one draw.

The cylinders were at first capped off and severed into flattening lengths by using a hot glass thread; this, however, proved too slow and cumbersome for commercial operations, and an appliance was devised by which the heated streak was produced by passing an electric current through a resistance wire held in contact with the cylinder. After a long period of experimental work, this method was finally adapted satisfactorily to the operation and has been in general use ever since.

The next step—and a most important one in increasing production—was to increase the diameter of the cylinder. It was not possible to flatten a single strength cylinder that was much larger than the standard size of 14 inches in diameter by 60 inches long. It was suggested, however, that there would not be any difficulty in flattening, if the dimensions should be reversed, and flattening lengths produced which would be 19 inches diameter by 42 inches long, employing of course pots of larger diameter and containing a larger quantity of glass. This method was tried out and proved so successful that it was immediately adopted in all the factories operating machines. The size of the cylinders has since then been considerably increased, so that today, using a 36 inch pot, single strength cylinders are made up to 21 inches in diameter by 460 inches long, and double strength up to 24 inches in diameter by 320 inches long.

Closer regulation of the air supplied to the interior of the cylinder: Lubbers had discovered three fundamental facts in his earliest experiments: First, that the air supply must be held at constant pressure; second, that unless the quantity of air supplied to the interior of the cylinder was constantly and uniformly increased during the drawing operation, the cylinder would taper off to a point; and third, that no ordinary type of hand-manipulated valve on the air inlet line would regulate the increase delicately enough. We have seen how these conditions were provided for by using a gasometer for regulating the air pressure and the special automatic graduating valve for controlling the rate of increase of the air supply.

As the length of the cylinders was increased, another complication entered. It was found that even with the graduating valve opening and increasing with automatic precision the amount of air entering the cylinder, the pressure at the point of draw was not constant, but was applied in a series of surges which produced corrugations in the cylinder, termed "pulsations." For the purpose of better understanding the cause of these, let us consider the condition of the glass at the point of draw, and some of the factors affecting the air pressure inside the cylinder.

In Fig. 3, *A* represents the wall of a cylinder being drawn from the bath of liquid glass *B*. The surface tension of the glass in the meniscus outside of the cylinder is N, and N' the surface tension of the meniscus inside the cylinder. Now N will always be greater than N', because the surface of the glass in the pot outside of the cylinder cools by free radiation and convection in the atmosphere, while the surface of the glass inside cools by radiation through the cylinder and convection currents set up by what air is confined within the cylinder. The difference is doubtless very slight at the beginning of the draw, but increases gradually as the draw progresses. Now since N is greater than N', the wall of the cylinder will be gradually pushed over towards N', unless held out by pressure. If we call M and M' the horizontal components of the force due to surface tension on the outside and inside of the cylinder respectively, then $M - M'$ will be the force that tends to contract the cylinder. If P is the air pressure introduced, then

$$M - M' = P$$

As $M - M'$ is constantly increasing, the pressure must be increased in the same proportion, if the cylinder is to be held to a uniform diameter.

Several factors, however, affect this pressure. Among these are the following:

1. Factors that produce or increase pressure:
   Air admitted under pressure through the graduating valve.
   Expansion due to heating the air by the hot glass in the cylinder and pot.
   Expansion of water vapor in suspension.
2. Factors that reduce pressure:
   Elongation of the cylinder.
   Cooling of heated air currents that rise through the cylinder.
   Lowering of average temperature of the air contained in the cylinder.

It will be seen that here are several opposing factors, and factors impossible to control, especially when we consider that the average pressure maintained in the cylinder during the draw is not much over a quarter of an ounce. The practical effect was the formation of pulsations referred to above. Why or how the air develops this pulsating or breathing flow is not even yet understood; however, Lubbers devised a means for overcoming the trouble sufficiently to meet the requirements of practical operations. That was to introduce an excess of blowing air and then allow a portion of it to escape through a vent hole. With the discovery of this principle, Lubbers completed the devising of a system of air control that stands today unchanged except in perfecting and applying improved mechanical details required by the huge cylinders now being drawn.

Better regulation of the drawing speed: In the first Lubbers machine there was no variation in the speed of the cross-head that carried the blow-pipe. It was not long until the practice of gathering a ball of glass on the blow-pipe was abandoned, and the pipe lowered directly into the glass, and when this was done it was found necessary to vary the speeds. Three speeds were used at first—one to form the neck, one for the cap, and one for the body of the cylinder. This was later changed so as to use one speed for the neck and cap, one for the body of the cylinder, and one to thin the lower end for shearing off.

It was also observed that the glass in the pot was gradually cooling as the drawing progressed, and therefore the walls of the cylinder were gradually thickening. The speed was therefore gradually increased, the increase being adjusted so as to compensate for the increasing viscosity of the cooling glass, and thus produce a cylinder of even thickness longitudinally.

Two factors control the thickness of the glass in a cylinder, first, the viscosity of the glass—governed by its temperature, and second, the speed of draw. The same thickness may be drawn from glass of different temperatures, if the speed is regulated to compensate for the variations in viscosity. The problem is, however, complicated by the necessity of drawing glass of even thickness around the entire circumference, by the necessity of preventing excessive cooling strains, and of avoiding loss of time as far as possible. In early operations there was considerable difficulty in keeping the thickness of the product up to standard single strength, and there was quite a little loss due to the production of thin glass that could not be marketed. As the machine became perfected, it was not only possible to produce good standard single strength, but double strength and heavier grades as well, up to 3/16 inch.

Several types of mechanism for raising the cross-head were tried—the one finally adopted being a motor driven-geared hoist. This was provided with a friction clutch held in position by a strong spring; an electro-magnet was used to release the clutch so that the cross-head could be lowered after the draw. The three speeds were first provided by driving the motor with current at three voltages—15, 60 and 220—and the increase of speed during the draw was provided for, first by using a conical winding drum for the cross-head cable, later by using a series of graded resistances on the 60-volt, or drawing circuit. Finally a standard hoist was adopted that used only one voltage up to the point of thinning the cylinder to sever it from the glass in the pot, and provided with a special drum on which the cable travels over an irregular spiral so designed as to impart the necessary changes in speed of vertical travel to the cross-head carrying the pipe.

Handling the Cylinder after completing the draw: In the early Lubbers apparatus there was a cord attached to the blow-pipe during the draw, this cord passing through an overhead pulley. After the draw was completed the pipe with the cylinder attached was detached from the cross-head by pulling this cord and lowering, while still attached to the cord, to a horizontal position. The hoist with the magnetic clutch control made it possible to lower the cylinder by simply swinging out the lower end, using curved supports, "taking down hooks," to support it, and slowly lowering the cross-head at the same time, on which the pipe and cylinder still remained suspended. This was hard and dangerous work for the men who handled the taking down hooks, and considerable experimenting was done with a view to providing apparatus for taking down the cylinders mechanically. A device that was finally adopted and which is now in general use proved a very simple and safe means of handling the heavy cylinders now being made.

This brief outline gives a very inadequate idea of the immense amount of study and research expended on the various problems involved, and the numerous alterations in the mechanical details that were found to be necessary while the machine was being developed and conditions of machine operation determined. It was a tedious and difficult task, but one by one the difficulties were overcome until finally machine operation attained such a degree of success as to dominate the window glass business of this country and has reached out to new fields abroad.

Lubbers' first type of machine, as has already been stated, made cylinders similar in size and workmanship to those which the single strength hand blowers were making at that time. A present day machine draws cylinders which are over twelve times as large, working with the precision and regularity that can only be obtained by mechanical operation.

Machine operation has immensely increased the output per tank and output per man in the blowing room. The machine blower, operating four machines, displaces on an average eight hand blowers, and not only this, he produces a great deal more glass than the eight hand blowers could possibly make. The whole labor force of a present day machine blowing room is less than half the labor force in the blowing room of a hand operated plant. Under hand operation a tank furnace was rated as so many blowers' capacity. A 48-blower tank, for instance, was a tank designed to melt sufficient glass to supply 16 blowers on each of the three working shifts; it was estimated that if the blowers all worked to the limit of capacity fixed by union rules it was as much glass as the tank would melt. The same tanks after being remodeled—not enlarged, or only slightly enlarged—have yielded an output in finished glass that has shattered all records in hand blown operation, and completely upset all previous ideas of tank capacity.

Not only in point of capacity, but as regards quality of product as well, has the machine scored a remarkable success. In the early operations a great deal of doubt was felt as to whether machine glass would ever equal hand blown glass in quality. Now the standard is set by machine made glass, which is recognized as the highest and most uniform quality produced in this country or abroad.

A wider range of thickness of glass is also produced by machine than can be made by ordinary hand blowers. Glass as thin as 1/23 inch and as thick as 3/16 inch is made regularly together with all intermediate thicknesses between these limits for which there is a demand. Ordinary hand blowers make two thicknesses, single strength (1/12 inch) and double strength (⅛ inch). Not many hand blowers can make glass heavier or lighter than these standards.

On account of the better quality and wider range of thickness of machine glass its use has been constantly extending. The bulk of the product of course continues to be used for glazing, picture framing and similar purposes. In addition, however, the lighter thicknesses are now very generally employed for photographic plates, stereopticon slides, and microscopic slides, all of which previously had been imported from Europe. Faces for clocks, gages, dials, etc., are likewise largely furnished from machine glass. The heavy glass finds a wide use for automobile lamp doors, wind shields and as a substitute for plate glass.

The invention of the window glass machine and its perfection to the present high standard of efficient operation is one of the most notable industrial achievements of recent years.

Colloidal Chemistry in Paper Making*

An Important Function in Manufacturing Processes

By Judson A. Deeew, B.A.Sc.

It is the object of this paper to point out some of those problems that are met with in the manufacture of pulp and paper, in which coloidal chemistry has an important function.

The cellulose materials of fibrous character from which paper is made are gel-forming colloids. The only exception to this would be that paper which is made from asbestos, where crystalline material having a fibrous structure is felted into a continuous web, by paper-making processes. Even in this case, however, it is necessary to add colloidal material in order to obtain a satisfactory product.

The paper-making fibres proper consist of cellulose or ligno-cellulose, either natural or prepared. Cotton is the natural cellulose, but cellulose fibres may be produced from the various ligno-cellulose fibres, by eliminating the products of lignification.

The gel-forming properties of cellulose and its compounds are already well known from the extensive use in the arts of the solutions of nitro-cellulose, acetyl-cellulose, and cellulose xanthate (viscose). These products are the result of chemical treatments which eliminate entirely the fibrous structure in producing the colloidal solution. These processes have very little importance in paper-making, for there the colloidal properties required are developed by mechanical treatment, with but slight alteration in the fibre structure. Under grinding action the fibres may swell by the absorption of water until they have a greatly increased weight, the phenomenon being known as hydration.

For making many kinds of paper, fibres containing more or less water of hydration are required, for the colloidal properties of the fibre produce both transparency and increased strength in the product, and at the same time reduce the capillarity. In those kinds of papers where opacity or capillarity are desired, or where the rate of production is paramount, it is obvious that structure is the essential element and that hydration must be avoided. For illustration, book papers should have bulk and opacity. Blotting paper must have the maximum absorption or capillarity, and news paper must be made at the maximum speed. In such papers the fibres lie rather loosely upon each other, so that as a result the book paper has a soft feel and is not transparent, the blotting paper has a maximum of interstices, and the news paper has given up the water with which it was associated on the paper machine with the greatest of readiness. This is all due to the natural stiffness of fibres which may contain water to the point of saturation, but have not been swelled with water of hydration.

Those papers which have acquired special properties as a result of the development of the colloidal properties in the cellulose, such as grease-proof, writings, bonds, wrappings, etc., have greater density, hardness, rattle, translucency, and strength than those already mentioned as made from unhydrated material.

The greatest density and translucency are seen in the grease-proof or "lacine" papers. The voids in these papers have been filled by pressing tightly together in the manufacturing process the cellulose fibres which have been previously beaten until they have taken on a gel-like character. The density of these papers is such that they do not absorb oils, and they have become known as grease-proof papers. Writing and bond papers must be hard and fairly strong, and consequently the paper stock from which they are made must receive a considerable amount of hydrating beating treatment.

Wrapping papers vary considerably in character, but that which has the greatest strength and wrapping qualities, is the one which has been made from fibres that have been brought to a very coloidal state by long beating, without reducing the length of fibre. Such paper is known in the trade as "brown" or "white kraft."

One kind of wrapping paper, known as "water finish," is made translucent by wetting the paper and crushing the fibres together by means of hot calender rolls. In this case the colloidal property of the cellulose is made evident by means of pressure alone. No increased strength, however, is obtained in this way such as results from the drying together of well hydrated fibres.

Methods of hydration. The usual method employed for making cellulose fibres more colloidal in character, is to mix, crush, or beat the fibres in cold water. The more drastic the grinding and crushing action, the more rapidly will the material become gel-like in character. This action may be accelerated by chemical means, as for instance by making the cellulose absorb a small amount of caustic alkali and then by treating with carbon bisulphide to obtain a thiocarbonate reaction. This does not dissolve the cellulose but develops a very dehydrated condition in the product.

Some hydration takes place in cellulose fibres by mere contact with cold water, but the amount of dehydration is limited and the time factor is long. The amount, however, is enough to cause trouble when a hydrated product is not desired. For instance, in the manufacture of news print paper, which is produced at the rate of over 600 feet per minute, the extra amount of hydration obtained from allowing the wet pulp to be in the vats for 24 hours is sufficient to cause such sticking on the presses of the machine that considerable time and paper may be lost. This is why there is always difficulty in starting up fast machines on Monday morning, when the stock has been stagnant for 24 hours.

It has been found that ligno-cellulose fibre, such as jute or wood, does not gel so readily by cold mechanical treatment as does cellulose, but conversely to the cellulose, its hydration is accelerated by the application of heat. In the production of ground wood, it was soon found that the best results were obtained by just supplying enough water to the stone to carry the pulp away. As a result the friction of the grinding develops high temperatures at the grinding surface, which reduce the adhesion of the fibres, and a better product is then produced.

When wood which has been previously boiled or steamed is ground to pulp, the fibres are found to have a more pliable and hydrated character and they will make a stronger paper than that produced from untreated wood. The brownish color of steamed ground wood suggests that some hydrolysing action had been the indirect cause of hydration.

Coating materials. Glue and casein are two well-known colloids which are used for binding white pigments upon the surface of papers known as coated papers. After being impregnated by these colloids, the dried papers are more resistant to the penetration of oils, and consequently they take clearer impressions from printing inks. These colloids are seldom used by mixing them in the wet paper stock, except in very small quantities where it is desired to increase the colloidal properties of other materials.

Fillers. Papers are often loaded with such fillers as China clay, talc, or other insoluble substances, in order to impart special properties such as opacity and a smooth surface.

It is desired in such cases that as much of the loading as possible be retained in the paper, and not carried away in the water draining from the paper machine wire. Some clays are more colloidal in character than others, but the collodial properties may be developed in any clay by the use of a small amount of caustic soda. There is still some doubt as to whether this degree of dispersion is desirable or not, but it is probable that the colloidal filler will give the best results if it is used in conjunction with the coagulants used for sizing the paper.

Sizing or waterproofing. To ensure that writing paper will resist the penetration of ink by capillary attraction of the fibres, and also to assist the ink to dry on the surface and thus give the line with proper depth of color, the fibres are coated while in the beating engine with a water-repellant substance which will destroy their capillarity. The material which is universally used for this purpose is ordinary colophony rosin, and it is distributed throughout the paper-making material in the form of a coloid. In order to produce colloidal rosin it must first be brought into solution, the usual means being either a partial or complete saponification. The amount of saponification required will depend upon the means available for diluting the soap, without forcing any rosin from solution.

When ordinary means of dilution are employed, at least three-quarters of the rosin should be saponified, but there are means available for diluting a rosin soap, when but one-half of it is saponified, in such a manner that the unsaponified portion will remain in solution in a soap diluted to 50 or 100 times its volume. If this unsaponified rosin is not visible as suspensoids it must be in colloidal solution. If this product is now coagulated by means of a salt of aluminium, it will produce a highly colloidal precipitate of rosin and alumina. If this material has been deposited evenly over the paper fibres, it will destroy their capillarity and produce a resistance to the penetration of water and inks (sizing process). When rosin is in colloidal solution in a highly diluted soap, a portion of it can be taken up by the fibrous material by absorption. The effect of rosin, deposited in this way, upon the capillarity of the fibres is very great, because its distribution will be perfect. The efficiency of the coagulated rosin will depend largely upon its bulk and degree of hydration, and we have in this way an explanation of the fact that rosin in the form of coarse emulsions is ineffective for sizing purposes. It is obvious that a particle of rosin which has been floating in suspension, cannot be precipitated as a colloid.

The older methods of making and using rosin soap for waterproofing necessitate a more or less complete saponification of the rosin. From such solutions, even when greatly diluted, the fibres can absorb but a small amount of rosin, and when the solutions are coagulated with aluminium sulphate, only about one-third of the rosin is thrown out of solution in the form of hydrated resin acids, the rest being deposited in the form of aluminum resinate, which is often basic in character, and is but moderately efficient as a water repellant. From our knowledge of the properties of resinates as compared with rosin itself, we would expect that a colloidal precipitate of rosin to hold its water of hydration more tenaciously than the colloidal resinate. If this is true then the colloidal rosin will withstand the drying action of the paper machine more effectively and will not crumble so easily by dehydration. The observed facts are very well explained on this basis.

In the past the literature on this problem has been qutie confusing, because the subject has been considered entirely from the standpoint of chemical reactions, without any reference whatever to the physical state of the material.

Colloidal by-products in pulp making. Sulphate Waste. In the production of cellulose from wood by the bisulphite process, about 60 per cent. of the wood becomes soluble, in the form of a sulphoniclignone complex. This material is generaly a waste product, but some uses have been developed for it based upon its colloidal properties. It is used as a binder in briquetting, in road-making, and in foundries in making cores. It has adhesive properties somewhat similar to those of dextrin, although it has not the same adhesive strength. If it could be bleached or decolorised, however, it would make an excellent substitute for other adhesives where only moderate strength is required. At the present time there is a great demand for this material in the concentrated liquid form or in the powder. The powdered product can be made by spraying the liquors into chambers with hot gases.

Black soda liquor. In the manufacture of cellulose from wood by the use of caustic soda, the lignin becomes dissolved in the form of sodium compounds. At the present time the organic matter is burnt off in incinerators, the alkali being recovered as carbonate and recausticised. If this organic waste is distilled instead of being calcined a fair amount of wood alcohol and acetone can be obtained from it. A distillation treatmen, however, is very difficult to apply owing to the great viscosity of this colloidal mass, and most of the work in this direction up to the present time has not resulted in the establishment of a profitable process.

Losses from colloidal dispersion. In the manufacture of both chemical pulp and ground wood, there are certain mechanical losses due to the fact that some of the material has lost its original structure and exists as minute particles in the dispersion medium. In the straining or washing of the pulp this fine material will be largely carried away in the waste waters.

As regards mechanical pulp this is shown by the fact that the difference in yield between coarse and very fine grinding may be as much as 10 per cent. The difference in yield of cellulose from the cooking processes, however, may be as much as 20 per cent. with varying treatments. When the cellulose itself is attacked by an excess of the chemicals or when these are improperly employed, a part of the cellulose

*From the *Journal of the Society of Chemical Industry.*

may be dissolved and part lost as a structureless colloid.

In the mechanical process of making paper on a machine, there are always losses of colloidal and suspended matter in the water draining from the machine wire. It is to be hoped that means may yet be devised for recovering this material in an efficient and satisfactory manner, but its nature is such that it does not respond readily to either straining, filtration, or sedimentation systems.

A full appreciation of the physico-chemical problems involved in these various processes should aid materially in arriving at their proper operation and control, and if any of this discussion serves to make the art of paper-making a little more clearly understood the object of this paper will have been fully attained.

The Development of the Army Dog

THE world is coming to recognize the fact that dogs are playing an important part in warfare. Efforts are being directed in several countries to developing a type of dog which will meet the most exacting requirements of the military authorities. In this country one of the most active in this work is Mrs. Anita Baldwin, owner of the Anoakia Kennels of Santa Anita, Cal., and the Chairman of the Los Angeles Branch of the American Red Star Animal Relief.

At her kennels splendid specimens of Airedales and old English sheep dogs are being crossed, with the hope that from them a superior type of army dog will be produced. The old English sheep dog is of ancient origin, having been used for centuries by the herders of England to care for their stock. The dogs have followed this training so long that each generation has improved until they have become watchdogs by instinct. They are extremely intelligent and many stories have been written about them portraying their unusual sagacity. Mr. Chris. Shuttleworth, the kennel manager of the Anoakia Kennels, says, "With the intelligence of the English sheep dog, rugged constitution and easy manner in which they adapt themselves to any climate, we are looking forward to producing an ideal dog when they are crossed with the Aierdale, who himself is at home in any climate."

Germany was the first country to recognize the value of the dog in military operations. For several years before the outbreak of the war dogs were being trained for this service, though their use was chiefly for Red Cross work. At the present time they are said to have 2,000 trained animals in the field. At the begining of the war France had but one dog trained for military purposes. Today it has hundreds of them that are serving in the most practical way in various branches of army service.

The real work of the dog in war can best be understood from the description written by the first President of the French Court of Appeals, Cunesset Carnot, in a small manual on the training of dogs for defense. He says, in part, with reference to this subject:

"The commonest service which is required of the dog is to be an auxiliary of our advanced sentinels. This dog every night occupies a more or less long position in a 'poste d' ecoute,' listening point, in a hole made by shells, behind a rock or a tree, in a ditch, etc. The night is dark, the fog thick, and the sentinel, whatever be his power of vision, cannot see or hear the enemy patrols who advance. The dog, on the contrary, when he has passed through proper training, will hear, for the dog's power of hearing is effective at a distance of 100 to 150 yards, and he hears the smallest sound. He will not bark, for then he would become dangerous for our posts, for our sentinels. He will only growl deeply, or he will otherwise, by scratching the ground, by moving his tail, by pricking up his ears, show that something is taking place, and the sentinel will then be on his guard, his attention will be awakened, and he will have time to send for reenforcements. After a few days of work in the first lines the sentinel dog, who will have understood his new occupation, becomes impassioned, and he shows this in many joyful ways, exactly like a gun dog when the shooting man takes down the gun.

TRAINING MORE DELICATE.

"As to the messenger dog (chien de liaison), his training is more delicate and requires more work; it is necessary that the dog possess certain natural qualities, such as a very well developed intelligence and a very powerful nose. The despatch dog works day and night. It is possible that he rests five or six consecutive days, and it is possible that he has to work two days and two nights without cessation, resting very little and eating only when he has time! The despatch dog must carry the despatches rapidly between the corps commanders, he also carries the small postal bags, artillery letters, etc., when the telephone is cut by the barrage fire or when it is impossible or dangerous to establish telephone lines. An intelligent and fast courier replaces the 'agent de liaison,' and even the appetizing smell of the 'soupe' would be unable to make him deviate from his route. He is conscious of his duty, which he accomplishes with courage and rapidity.

"As to the patrol dog, he searches about the ground and lets the patrol chief know that there is nothing suspicious about, or, on the contrary, that the ground is well guarded by the enemy. The patrol dog must be able to take the 'offensive,' and also know how to be on the 'defensive,' he must know how to throw himself on an enemy patrol, on an isolated sentinel, whom he must hold with his teeth until the arrival of his own patrol.

"The ambulance dog (chien sanitaire) searches on the field of battle after the ambulance men have picked up all the visible wounded. Thanks to his nose, he is able to find a wounded man in a ditch, under some straw, etc.

"We also possess draught dogs (chiens de trait), which have come from Alaska and Labrador, and which are being used for bringing up munitions, food, etc., when the snow in Alsace and in the Vosges allows only the passage of sleighs."

The American Red Star Animal Relief proposes to establish kennels for the training of dogs employed in all branches of the army, except those needed in Red Cross service. Dogs for the latter work are already being trained by the Red Cross. Dogs for sentry, messenger and draft purposes will be provided in large numbers to the various army camps where they are most needed. These dogs will be known as Red Star dogs, and will wear the Red Star harness. A number of humane organizations have indicated their willingness to assist in this important work, and it will only be a short time before an adequate number of dogs can be placed at the disposal of the government. It will, of course, be necessary to erect kennels and hospitals for their care in the field as the French and other combatants have done for the dogs used in their armies. —*The National Humane Review.*

New Fulminates and Azides

IN addition to sodium fulminate, the hitherto unknown simple cadmium, thallous, and cuprous fulminates have been prepared by the action of an amalgam of the metal on silver or mercury fulminate in presence of ethyl or methyl alcohol and precipitation of the new fulminate with ether. Treatment with the amalgam is carried out in a rubber-stoppered bottle in a shaking machine, not more than 1 to 2 grms. of mercury or silver fulminate being treated at one time, and all the operations being performed in an atmosphere of dry hydrogen. Cadmium amalgam is prepared by electrolysis of the sulphate with mercury cathode; the amalgam containing 20 per cent of cadmium is washed with water and methyl alcohol and lastly with methyl alcohol distilled over barium oxide. Two grms. of mercury fulminate with the addition of 30 c. c. of anhydrous methyl alcohol, cooled by ice, is shaken with the amalgam for about 25 mins. until a test of the filtered solution shows no reaction of mercury with stannous chloride. The product is passed through a filter into dry ether, in a current of hydrogen, and the washing of the fulminate with ether is conducted with the same precautions. After drying *in vacuo* the fulminate still retains about 2 per cent of methyl alcohol from which it is not completely freed even by heating at 55° C. over phosphorus pentoxide *in vacuo* for 24 hours. The analysis of the soluble fulminates is made by Volhard's method, in methyl alcoholic solution, using alcoholic silver nitrate. Cadmium and thallium fulminates are soluble and subject to hydrolytic decomposition in presence of moisture; cuprous fulminate is insoluble and can be prepared by shaking the amalgam with mercury fulminate in presence of water in an atmosphere of hydrogen. Soluble azides of the heavy metals, of normal composition, have been prepared by the action of azoimide (hydrazoic acid) on the carbonates or basic azides in presence of ether. Normal azides of nickel, cobalt, zinc, and manganese are described. The azoimide may be prepared without danger by gradually introducing 5 grms. of finely powdered sodium azide into a mixture of 100 c. c. of ether and 2 c. c. of concentrated sulphuric acid, shaking and filtering off the sodium sulphate. The treatment with the metallic carbonates requires 3 to 4 days in the shaking machine; the material must be dry and very finely powdered. The end of the reaction is indicated by solubility in water; the suspended azide is filtered off and washed with ether. In the case of manganese it is necessary to start from the basic azide because the reaction proceeds too slowly with the carbonate; basic zinc azide may also serve for the preparation of the normal zinc azide. Nickel azide is partic larly sensitive to rubbing and explodes violently. Th solutions of all these normal azides are really hydroly giving basic deposits. Ferric and chromic azides normal composition could not be obtained.—Note i *J. Soc. Chem. Ind.* on a paper by L. WÖHLER and MARTIN in Ber.

High Temperature Measurements Without Platinum Instruments

A NEW thermo-element recently introduced for th measurement of temperatures between 900° C. and 1,100 C., is constructed of nickel and nickel-chromium and i very reliable. An improved and simplified form o optical pyrometer has also been introduced, in whic the regulating electrical resistance is in the form of a ri on the telescope tube, which is made of aluminium. —N NEUMANN in *Chem. Zeit.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, SEPTEMBER 22, 191

Published weekly by Munn & Company, incorporated
Charles Allen Munn, President; Frederick Converse Beac
Secretary; Orson D. Munn, Treasurer,
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Ma

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.
Scientific American (established 1845) . . . . 4.
The combined subscription rates and rates to foreign countri including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Munn & Co., Inc., 233 Broadway, New Yo

The purpose of the Supplement is to publi the more important announcements of disti guished technologists, to digest significant ar cles that appear in European publications, an altogether to reflect the most advanced thoug in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than Janua 1st, 1916, can be supplied by the H. H. Wilson Co pany, 39 Mamaroneck Avenue, White Plains, N. Please order such back numbers from the Wilson Co pany. Supplements for January 1st, 1916, and subs quent issues can be supplied at 10 cents each by Mu & Co., Inc., 233 Broadway, New York.

Table of Contents

Osmotic Pressure in Animals and Plants.—By W. R. G. Atkins
Earth Pressures
Stability and Buoyancy of Submarines
Some of the World's Most Notable Bridges.—3 illustrations
Potash from Seaweed
Integrating Tachometers.—By Commander L. A. Kaiser, U. S. Navy.—1 illustration
Rivets in Ships
Nature of Coronium
A Substitute for Litmus for Use in Milk Cultures.—By W. M. Clark and H. A. Lubs
Peat as a Coal Substitute
Variation of the Size of Drops
Thorium Lead
Destroying the Crow and His Cousins.—7 illustrations
Soap Treatment for Infected Wounds
Commercial Alloy Steels.—By Edgar D. Rogers
Eskimo Music
Chemical and Physiological Detection of several Alkaloids
Making Window Glass by Machinery.—By Robert Linton. 3 illustrations
Colloidal Chemistry in Paper Making.—By J. A. Decew
The Development of the Army Dog
New Fulminates and Azides
High Temperature Measurements Without Platinum Instruments

nber 22, 1917

side is partic
violently. Th
lly hydrolyse
mic asides
ned.—Note
ÖHLER and F

s Without

duced for th
° C. and 1,100
romium and
ified form
ced, in which
form of a ri
minium.
Chem. Zeit.

RICAN
T

BER 22, 1917
ncorporated
onverse Bo
eror.

nd Class Matte
ic.

tions
) per year $
reign countri
application.
raft or check.
New Yo

s to publi
of disti
ificant ar
cations, a
nced thoug
world.

American

than Janua
Wilson Co
Plains, N.
Wilson Co
6, and sub
ach by Mu

at we are i
every bran
is compo
xperts, th
ll patent
ature of t
sed, technic

e world, w
ade-mark
o the Unit

& Co.,
Solicitors,
Broadway,
York, N.

W. R. G.
ustrations
A. Kaiser
By W. M.
ions
lkaloids
rt Linton
Decew
tinum